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THE

Progressive Fish-Culturist

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COMPETITIVE SURVIVAL ABILITY OF BROOK, BROWN, AND RAINBOW TROUT FINGERLINGS IN A STREAM-FED RACEWAY

Keen Buss and Raymond McCreary
Benner Spring Fish Research Station, Pennsylvania Fish Commission
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TROUT STREAMS are sometimes stocked with hatchery-reared fingerling trout of more than one species. The success of these plantings may be influenced by (1) the ability of one species to compete with another, (2) the adaptability of a trout species to the particular water environment where it is introduced, and (3) the variation in sizes of the species planted. It is almost impossible for any production hatchery to produce three species of trout fingerlings of the same age and size at any one time.

In May and June 1957, an experiment was initiated to test the ability of three species of fingerling trout to survive when in competition with one another. Brook trout (Salvelinus fontinalis), brown trout (Salmo trutta), and rainbow trout (Salmo gairdneri) hatched and maintained at the Benner Spring Fish Research Station were placed in a long earthen raceway. They were not given any food or care.

It was hoped that this experiment would indicate what might occur if all three species were planted as run-of-the-hatchery-size fingerlings in a natural environment, as the three factors listed above were present and are normally influential in trout-stream plantings. It was thought that this experiment should also indicate the natural productivity of the stream water in the raceway during a 1-year period. Further, it was thought that the experiment should disclose what may be expected when these three species of fingerling trout are planted in reclaimed streams.

Description of Stream Raceway

The stream raceway is an earthen aqueduct, 2,775 feet long and 10 feet wide at the bottom, with a 1 to 1 slope on the sides. The raceway has an 18-inch fall and is 24 inches deep at the head and 42 inches deep at the lower end. The temperature of the water ranged from 32° to 78° F. Water flow ranged from 5,000 to 9,000 gallons per minute. The source of the water is Spring Creek, a trout stream near Bellefonte, Centre County, Pennsylvania. (Brown trout reproduce naturally in Spring Creek; brook and rainbow trout are also present through stocking.) A diversion dam has been constructed to divert water into the raceway. The raceway contains approximately 2.1 acre-feet of water. A typical water analysis is as follows: pH, 8.8; total methyl orange alkalinity, 170 parts per million; total hardness, 194 parts per million; dissolved oxygen, 13 parts per million at 62° F.; and resistance, 2700 ohms per centimeter cube.

Procedure

On May 29, 1957, 20,000 brown trout fingerlings weighing 68.5 pounds were put in the raceway; on June 5, 20,000 brook trout fingerlings weighing 145 pounds were

introduced; and on June 14, 20,000 rainbow trout weighing 520 pounds were added. These trout were not fed artificially at any time after being planted. A heavy growth of Potamogeton provided cover for the fish and may have harbored many insects.

On June 11-13, 1958, the fish were removed from the raceway. They were then sorted by species, counted, and weighed.

There were two uncontrolled factors which may have affected the results: (1) It was impossible to select the three species of trout for the same size and age; and (2) when the raceway was drained and the fish were removed, it was found that 13 large 2.5-year-old rainbow trout weighing 8.8 pounds and 8 brown trout weighing 8.8 pounds were present. How these fish entered this water area is not known. Before the experiment was begun, the raceway had been treated with dehydrated lime to kill stray fish. Fishermen may have thrown some trout over the protective fence.

The presence of these larger fish may have had an effect not unlike that found under natural conditions. These larger fish may have usurped some of the better food and cover locations and preyed on less wary fish.

Although the experimental fingerlings were not marked, it is not probable that other trout fingerlings entered the experimental raceway. Both ends were screened with No. 8 mesh galvanized hardware cloth and planked 6 feet above the screens to prevent the trout from jumping over.

Results

Although more rainbow trout survived than brown trout (see table), many of the rainbow trout were in an emaciated condition (figures 1, 2, and 3). It is doubtful that many rainbow trout would have survived another year. The brown trout was the only species which showed an overall increase in weight. The loss in number of brown trout could be attributed to the fact that they were much smaller than the rainbow trout when planted, and thus were subject to more predation from the other fingerlings or larger fish. The 19 brook trout which survived were in fair condition.

THE RESULTS OF COMPETITIVE SURVIVAL TEST OF BROOK, BROWN, AND RAINBOW TROUT

	Rainbow trout	Brown trout	Brook trout
Number:			
Planted--------	20,000	20,000	20,000
Recovered------	7,926	4,536	19
Pounds:			
Planted--------	520.00	68.50	145.00
Recovered------	295.25	102.25	.25
Fish per pound:			
Planted--------	38.5	291.9	137.9
Recovered------	26.8	44.4	76.0

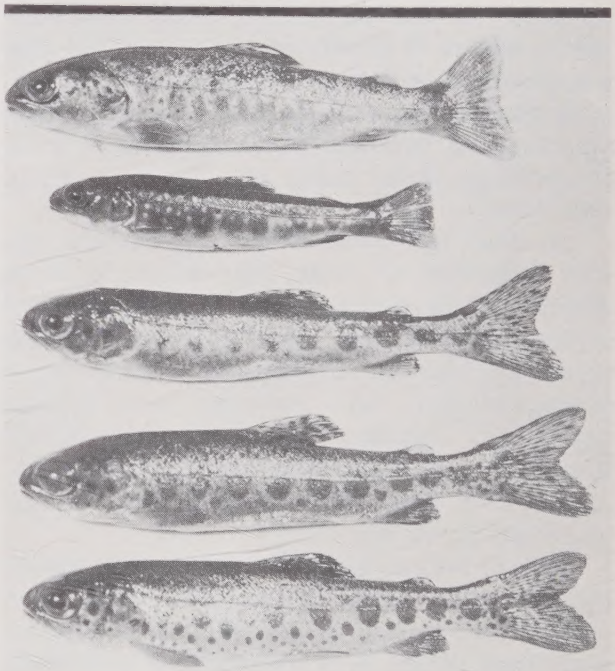

FIGURE 1.-- Comparative condition of trout removed from raceway. From top to bottom: Brown trout, brook trout, and three stages of emaciation of rainbow trout.

(Official photographs, Pennsylvania Fish Commission: Glenn Hoy)

The productivity of fish in this raceway was approximately 189 pounds per acre-foot. This should be an indication of natural productivity of this environment for fingerling trout over a 1-year period.

A comparison of the growth and condition of the three species is shown in the table opposite "Fish per pound: Planted, Recovered."

Discussion

The evidence from this experiment points out that there is a difference in the competitive survival ability of brook, brown, and rainbow trout in the particular environment where this experiment was conducted. The difference in the size of the fingerlings in this experiment can be discounted because the brown trout fingerlings which showed the best growth and condition were exposed to more natural hazards as a result of their smaller initial size.

Preliminary experiments now in progress in the Allegheny National Forest (Boccardy, personal communication) indicate that it is difficult to establish a brook trout population in soft-water streams when a brown trout population is present unless the streams have been reclaimed. After reclamation, brook trout, when planted alone, live and thrive.

Therefore, it becomes more apparent that interspecific competition plays a vital role in the species composition and survival. Brown trout need not necessarily be the species most adaptable originally to

FIGURE 2.-- Dorsal view of rainbow trout (left) and brown trout (right), showing comparative emaciation of the former.

FIGURE 3.-- Ventral view, illustrating comparative condition of rainbow trout (left) and brown trout (right).

the environment; but with changing stream conditions due to agriculture, industry, and the effects of expanding mammal populations (e.g., deer, beaver), this species is becoming more firmly established in a more suitable ecological niche.

The plantings in this experiment were from hatchery-reared fingerlings which had been hatched and maintained under a similar environment. Species hatched and maintained under natural conditions also receive similar environmental pressure. Consequently, it would seem that planting three species of fingerling trout in the same stream is a waste of time and money. It would be better to determine the species best suited for a water area and then plant that species to the exclusion of the others, as the other species would have a lower survival rate.

Summary

1. Twenty thousand each of brook, brown, and rainbow trout were placed in an earthen raceway to test their ability to compete with one another with no artificial feeding or care.

2. Forty percent of the rainbow trout survived, but most of these were in such an emaciated condition that their survival for another year is doubtful.

3. Twenty-three percent of the brown trout were recovered, and most of these trout were in good condition. The brown trout may have suffered more from interspecific predation because they were initially the smallest of the three species planted.

4. The surviving brown trout showed the greatest increase in growth. Also, the brown trout was the only species that showed an increase in weight over that planted.

5. The survival of brook trout was negligible, amounting to less than 0.1 percent of the original 20,000.

6. It is felt that had this experiment been allowed to continue for another year, the brown trout would have been the predominant species, with the other two almost eliminated.

7. One hundred eighty-nine pounds of trout per acre-foot were maintained over a 1-year period in this environment.

AN OUTBREAK OF COLUMNARIS DISEASE IN STONEROLLERS

In May 1959 thousands of stonerollers (Campostoma anomalum Rafinesque) died in a 10-mile section of Little River, Great Smoky Mountains National Park.

Biologists' surveys have shown that stonerollers are abundant in this section of Little River. The population has been estimated to be 71 pounds per acre of stream, and fish measuring as much as 8.3 inches in total length have been taken.

An investigation of the mortality disclosed that this minnow spawned during the first 2 weeks of May. Toward the end of the second week, many dead and dying stonerollers with external lesions became evident. This disease condition apparently was restricted largely to the spent fish. Immature stonerollers did not seem to be affected by the disease. Also, among the other species that were present in the stream, only a few hogsuckers (Hypentelium nigricans LeSueur) shared the affliction with the stonerollers. The mortality continued for 1 week.

Specimens were examined at the Eastern Fish Disease Laboratory, and it was determined that the mortality was due to columnaris. The outbreak was believed to be exclusive to Little River, as no evidence of mortality was found among the stonerollers or other species in nearby streams.

--ROBERT E. LENNON and PHILLIP S. PARKER, Bureau of Sport Fisheries and Wildlife, La Crosse, Wisconsin.

COLLECTION AND PRESERVATION OF FISH AND OTHER MATERIALS EXPOSED TO PESTICIDES

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THE EFFECTS OF PESTICIDES ON FISH have become important to fish conservation since World War II, when DDT first came into common use. With the development of other potent insecticides and the increasing use of massive dosages in more recent years, the threat to fish and fish foods has increased. Fishery biologists have conducted some studies on the effects of insecticides, but it has been impossible for fishery science to keep pace with chemistry and agriculture.

The past 2 or 3 years have seen an emergence of appreciation--on the part of sportsmen, fishery and other conservation agencies, entomologists, and legislators--of the gravity of the fish-pesticide problem. As a result, almost every State fishery agency has entered into some phase of research on pesticides and fish, and the Bureau of Sport Fisheries and Wildlife, the Bureau of Commercial Fisheries, and the Public Health Service have expanded and intensified their research on pesticides. Many fishery schools now support research in this field.

Fishery scientists assigned to pesticide investigations are in a relatively new type of study, and it is one in which little training is furnished in the curricula of fishery schools. The methodology for field and laboratory approaches is not well established for many aspects of the work, although some standard fishery procedures are often appropriate. The scope of fish-pesticide studies, as we recognize it, embraces the disciplines of field fishery biology, bioassay, biochemistry, and physiology. The fishery biologist, then, is one specialist on a team, and he is a cooperator and collaborator whose collection of specimens and other services are part of a chain of activities. The chemist or other specialist has certain requirements which must be met by other members of the team if he is to provide services in the most accurate manner.

The fishery biologist receives guidance in some nonfishery areas from publications such as that of Doudoroff and cowriters (1951) on methods for testing pesticides against fish, of Bliss (1952) on the statistical aspects of bioassay, and of Galtsoff and cowriters (1937) on methods for culturing aquatic invertebrates. This paper is a discussion of some methods that are useful in the treatment of fish and other materials which are to be collected and preserved for processing by histologists and biochemists. This phase of the chain is extremely important, because good sampling and proper preservation are required if accurate qualitative and quantitative results are to be obtained by the other specialists.

Some of this material was included in a paper delivered at the meeting of the Central Mountains and Plains Section of the Wildlife Society at Fort Collins, Colorado, February 20, 1960.

Background Information

One of the first essentials in participation in any pesticide study is to obtain a complete set of background information. This should include all of the physical, chemical, and biological circumstances surrounding the pest-control operation, the bioassay test, or whatever project is the basis for conducting the study. If it is a field study, a survey of the waters and environs should be made so that the biota, the water and soil chemistry, and the physical features are understood. If a field chemical treatment is made in connection with the study, a summary of the facts pertaining to the treatment should be prepared. This would include information about the kind of pesticide, its formulation, the amount of chemical applied (especially the amount actually reaching the water), the state of the weather during and after the operation (rain, wind, etc.), the method of application (airplane spray, power dusting, etc.), the success of the treatment in terms of its primary purpose, the distribution of the chemical in the water when it can be perceived, observations on immediate morbidity or mortality to invertebrates or to fish, and any other data which could have a bearing on the consequences to fish. If fish are exposed in laboratory tests, corresponding facts should be collected so that a complete compilation is on record.

The identity of organisms is usually important. Rather than use the terms "sunfish" or "aquatic vegetation," it is better to designate the species involved, when it can be determined. The fishery biologist is usually the best-qualified member of the team to make these identifications, and he usually has the advantage of working with fresh material.

After assembling this background material, the biologist should make it available to his associates as an automatic part of the collaboration. The chemist who is making analyses of pond water or fish tissues for toxicant content may be able to use information on water composition or source in choosing his best cleanup methods; without it, he may be delayed for days or weeks. The histologist who is interpreting effects of chemicals on fish cells or tissues may be assisted by knowing the length of exposure to the chemical or the type of formulation involved. I emphasize the importance of furnishing these data to other specialists concerned with the processing of collected materials.

Fish

Fish for chemical analysis for toxicants or for histological examination can be collected by seining, gill-netting, electric-shocking, or any other means which insures that no extraneous chemicals will be introduced to complicate the analysis or change tissue morphology. Poisons such as rotenone should not be used for collecting, as they may mask the effects of the toxicant being investigated. In general, only live or dying fish should be collected for this purpose; dead fish in which decomposition has begun should be avoided, because the chemistry of the fish changes in the process. Approximately 1 pound of fish should be collected for each sample for chemical analysis, where the whole fish is to be ground for analysis. When individual tissues are to be analyzed, it may require more than a pound of whole fish to furnish enough of specific tissues for the chemist.

Fish are best held in polyethylene bags or waxed cardboard containers for preservation by freezing. Lots of fish should be kept in individual bags or boxes for separation from each other during storage and shipping, thus avoiding contamination between and among lots. Excess water should be drained from the bag before it is sealed. Labels should be made for each sample on a good-quality bond paper. Soft black pencil is better for labels than most ink, which smears when wet. Labels should not be placed in the same bag with wet fish, for the writing may become illegible. Labels should be tied securely to the outside of the bag or, even better, placed between the bag and a second, outer bag, with the writing to the outside. This procedure provides for

ease and accuracy when acquisition is made in the chemist's laboratory, as the label can be read without first having to thaw the frozen sample. Thawing and refreezing may induce chemical changes that may affect the analysis.

When a method of preserving other than freezing is to be used, good-quality labels can be placed inside the bottle; but the collector working around pesticides must be careful not to transfer any pesticide from his hands to the label and then into the bottle.

For fish to be analyzed chemically, it is recommended that the fresh fish be frozen and stored in the frozen state. If freezing facilities are not available, preservation by drying or preservation in liquid is acceptable. Ethyl alcohol is the best liquid preservative; solution of formaldehyde is not desired. Specimens that are destined for the histologist should be placed in a good histological fixative, such as Bouin's fluid. Care must be taken to open the abdominal cavity for complete penetration, to provide a sufficient volume of fixative for the specimen, and to transfer the specimen to 75 percent ethyl alcohol after 2 to 7 days in Bouin's solution.

The transport of frozen fish should be by air freight or air express for long distances. The frozen specimens should be placed in a strong cardboard carton or drum with crumpled newspaper for packing and insulation and kept refrigerated with dry ice (10 pounds of dry ice for 10 to 15 pounds of fish). The container should be sealed with paper tape. A telegram should be sent to the receiving laboratory before or at the time of shipment so that there will be no delay at the destination, where the specimens will be placed in a freezer. It is also good practice at the time of shipment to forward a detailed list of the specimens being shipped; this can be sent by mail or in the shipment itself. The laboratory technician needs the list in planning the processing of specimens and in making preliminary interpretations of results. Fish preserved in alcohol or in a histological fixative can be shipped by a cheaper, slower method, such as express or bus. Shipment can be made in wooden boxes or cardboard cartons, with adequate packing material to avoid breakage of bottles. Here, again, a list of specimens should be sent to the recipient so that he can identify the lots of fish and establish priorities for analysis or examination.

Water

The collection and transport of water for quantitative chemical analysis for pesticides are beset with problems because of the chemical natures of pesticides. Two methods for collection of pesticide-bearing waters are being used. The most popular method consists of securing water from a lake, stream, or aquarium and sending it to the chemist in a glass or plastic bottle. The other approach is by pumping water from the stream, pond, or tank through an activated charcoal column. In the second method, the pesticide is adsorbed on the charcoal, which is then analyzed by the chemist.

In the first method, water may be dipped from the surface or just below the surface, or may be raised from depths in a Kemmerer or Nansen water bottle or with a pump. If oil solutions of pesticides are floating on the water surface, it must be decided whether to include the oil in the sample; if the oil is to be included, a widemouthed vessel is useful for taking the surface sample. The amount of water to be collected will be dictated by the nature of the toxicant, its concentration, and the chemistry of the water. A 1-gallon sample is usually sufficient for accurate analysis; but if so directed by the chemist, the biologist can sometimes secure as little as a quart. No attempt should be made to filter the water in a sample; if colloidal material or plankton is to be removed, the chemist can do it.

Waters containing some chlorinated hydrocarbons should be acidified when collected, in order to avoid the degradation of the toxicant at high pH values. This technique is recommended for DDT and toxaphene, and it will probably be

indicated for use with other pesticides as our knowledge of them increases. Acidification can be accomplished by adding 20 cubic centimeters of 1N H_2SO_4 for each gallon of water.

Some thought should be given to the choice of the container for storing and shipping water. Polyethylene bottles have the advantage of being unbreakable. This feature is outweighed, however, by their ability to adsorb chlorinated hydrocarbons to a serious degree--and thus lower the concentration of toxicant in the water to be analyzed. For example, at some concentrations DDT in water is reduced by 90 percent through this action; this renders a polyethylene container useless for storage of specimens. Glass gallon jugs or fruit jars have been used extensively for storage and shipping of pesticides in water. Actually, DDT has also been found to adsorb on the inner walls of glass containers, but to a much lesser extent than on polyethylene walls. Studies are being made with coatings on the insides of bottles to relieve this disadvantage. The other problem with glass--its fragility--must be kept in mind during handling, and glass-bottled samples should be carefully packed to prevent breakage during shipping. Another requirement for samples likely to be stored in glass for several weeks before analysis is that the glass be dark-colored. Because some pesticides, such as toxaphene, can be detoxified by light, the use of dark glass is recommended.

The labeling of individual water samples can best be done on the outside of the containers. If labels are placed inside the container, contamination may be possible. For gallon jugs, shipping tags wired or tied securely to the necks or handles are good labels; for jars, labels can be glued to the outside of the glass.

The charcoal-column method for collecting pesticides from water has been described by Braus, Middleton, and Walton (1951). The apparatus consists of a pump, a flow meter for measuring the amount of water sampled, and a glass pipe filled with activated charcoal. In use, a measured amount of water is passed through the column. The column is transported to the chemist, who extracts the toxicant from the charcoal. This method has the advantage of handling large samples; disadvantages are high cost, bulkiness and weight, and difficulty of efficient extraction in the laboratory.

Water samples can be shipped by surface express or bus; shipment by freight may increase chances for breakage.

Lists of samples should be sent to the chemist at the earliest opportunity.

Aquatic Vegetation

Aquatic plants for chemical analysis to determine pesticide residues are collected by the usual procedures. Rooted aquatics are taken with grappling hooks or with Peterson or Ekman dredges; floating filamentous algae and higher plants are raked in from a boat or while wading; phytoplankton are gathered in a plankton net by vertical or horizontal hauls; periphyton are collected by taking the substrates on which they grow.

Bulky plant material and periphyton on substrates should be placed in polyethylene bags or waxed cardboard containers, labeled, and securely tied. Here, again, when plastic bags are used, placing one bag inside another, with the label between, is the recommended method. Each sample should consist of only one species. Samples should be frozen for preservation and shipment, as with fish samples.

Phytoplankton can be dried and kept cool, or preserved in 75 percent ethyl alcohol in vials or bottles.

Size of sample should be sufficient for replicate analyses by the chemist. A double handful of higher plants will usually suffice. For periphyton, at least a square foot of surface is desirable. A half cupful or more of phytoplankton is recommended, where it is possible to secure this quantity.

Aquatic Invertebrates

Aquatic invertebrates for analysis of residue are collected with the conventional

equipment of the aquatic biologist. Bottom organisms in streams are taken with the Surber square-foot sampler, the Hess sampler, the square-yard sampler, or--in the case of affected animals drifting in the current--with a coarse-mesh plankton net anchored in the stream. Dead or dying invertebrates lying on the stream bottom are sometimes abundant enough to be harvested by hand.

Invertebrates in standing water are taken from the bottom by dredges; nektonic animals are taken by nets or by raising debris, dead branches, or thick aquatic vegetation; and those from limnetic areas are collected with Wisconsin plankton nets or other fine-mesh nets. Some fresh-water invertebrates, such as large pelecypods and crayfish, will usually not be taken by these collection methods, and will require traps, hand collection, or other techniques.

Although large volumes of aquatic invertebrates are usually difficult to obtain, especially if individual species are desired, a half cupful of organisms should be collected to provide enough for reliable chemical analysis. Preservation by freezing in polyethylene bags or cardboard boxes is the preferred method. If this is not feasible, 75 percent ethyl alcohol is an alternative. Formalin should not be used.

Bottom Sediments

Collection of stream-bottom and lake-bottom muds for quantitative analysis of pesticides is difficult. Sampling is complicated by problems in taking layers of uniform thickness. Core samplers which yield specimens 1 to 2 inches in diameter usually furnish samples that are too small; they are also of limited value for low-density soils. For deep water, Peterson or Ekman dredges give samples of good size but are not always truly quantitative because of the variation in penetration of the surface and the effects of water currents in disturbing the mud surface. In shallow waters, mud can often be scraped with the hand or with mechanical scrapers. Uniformity of thickness in the mud sample is desired for comparative studies.

Mud samples are best preserved by freezing in polyethylene bags or waxed cardboard containers. This method will prevent decomposition of organic materials in the sediments without affecting the chemistry of the pesticide sought. Labeling should be done as with fish and vegetation samples discussed earlier.

A cupful of mud should be obtained for each sample.

Other Materials

Special materials are best handled by individual techniques which may be recommended by the specialist who is to analyze the specimen. The U. S. Public Health Service (1956) advocates certain treatments for some samples, such as for adipose tissue (requiring about 2.5 grams of tissue preserved in CP-grade carbon tetrachloride); for blood for cholinesterase determinations; and for stomach contents, urine, and other materials that can be kept cool by "refreezants" (silica gel packaged in plastic or metal).

Summary

The increasing activities of fishery biologists in pesticide studies call for a review of the best methods of collecting, preserving, and shipping samples of materials to be analyzed for pesticide residues. The chemist and the histologist have certain processing requirements that aid in preventing chemical and morphological changes in collected materials and in assuring more reliable analyses. Recommended methods for the handling of stream and lake water, fish, aquatic vegetation, aquatic invertebrates, bottom sediments, and other selected materials are discussed.

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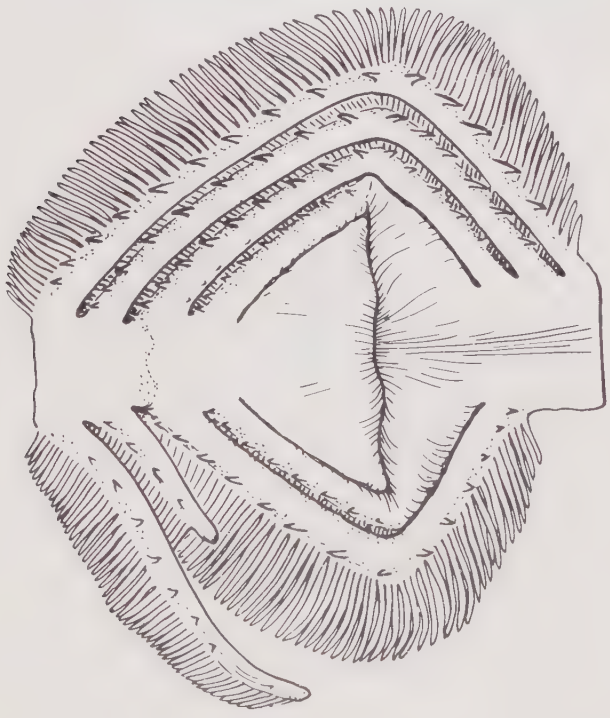
THE SURVIVAL OF A BROOK TROUT WITH TWO MUTILATED GILL ARCHES

A survival rate of 94.3 percent has been reported for trout caught on flies and bait under hatchery conditions. Also, a survival rate of 96.8 percent has been reported for trout caught on artificial lures and released under natural conditions. Nevertheless, many anglers believe that the survival rate of trout which have been hooked and released is low, especially if the gills have been injured.



Branchial apparatus of a brook trout with two gill arches partly removed. (Anterior view.)

In the summer of 1959 a brook trout, Salvelinus fontinalis (Mitchill), collected from Sagehen Creek, California, had dorsal segments missing from the first two of its left gill arches. These had been torn during a shocking operation in the previous summer, but the ventral stubs healed (see drawing). This 3-year-old trout, measuring 199 millimeters in total length and weighing 83 grams, appeared to be in normal condition except that it lost its equilibrium faster in a chloretone solution than did trout without gill injuries.

Twenty-two brook trout collected at the same time and place had an average length of 182 millimeters and an average condition factor (K) of 1.147, neither of which differs significantly from the length and K value of the injured trout. This indicates that brook trout which survive the initial trauma of the removal of two gill arches may live and compete satisfactorily with normal trout.

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HORMONE SPAWNING OF WARM-WATER FISHES: ITS PRACTICAL AND BIOLOGICAL SIGNIFICANCE

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THE USE OF GONADOTROPHINS TO INDUCE FISH TO SPAWN has many advantages in the culture of sport, food, bait, and tropical fishes. As fully ripe females of several species respond to pituitary injections by spawning within 12 to 20 hours, it is possible to predict rather accurately when a spawn is forthcoming. This procedure allows the fish-culturist to plan his work and stock waters according to a predetermined schedule, because the injections to some degree bypass the variables in the environment such as temperature, light, and rainfall. As both males and females respond to pituitary injections, some species can be hand-stripped--a practice which offers additional advantages. The hormone spawning of such species allows one to stock culture ponds with eggs and fry of uniform age and size. Since the brood stock are not in the pond with the offspring, the possibility of transmission of disease from brood stock to offspring is reduced and predation by the parent is eliminated. Hybrids can also be secured by handstripping wherever hybridization is feasible and desirable. Wild fish of some species that have not yet been domesticated may be spawned more easily by the hormone method. Frequently more uniform spawning has been achieved by the injection of pituitary materials into ripe fish which, owing to some environmental or physiological condition, fail to spawn without such treatment.

Until recently the hormone method has been used mostly by fish-culturists dealing with difficult-to-spawn species. However, reports have reached us--and inquiries have been received--concerning the application of similar techniques to obtain eggs and sperm for radiation and cancer studies, pollution work, and teaching materials. Other workers are interested in the production of sterile hybrids for the stocking of managed waters and in genetic and physiological investigations aimed at the production of better strains of fishes which grow faster, are more resistant to disease, or in other ways are more beneficial to man. Fish are particularly suited to such studies because large numbers can be produced from the same parents and these large numbers make statistical analysis both possible and valid. In many instances, the hormone spawning method makes it possible to work with species which heretofore have been difficult to spawn under restricted laboratory conditions. Also, this method will permit the investigator to extend the work over a longer period of time each year. In addition, the literature (for a complete review, see Pickford and Atz 1957, and

Sneed and Clemens 1959) suggests that with improved materials and procedures fish may be sexually developed and induced to spawn during any season of the year, thus greatly extending and enhancing the usefulness of the method and making available for experimentation many previously excluded species.

Biological Implications

South American and Russian fish-culturists have applied the pituitary method to the large-scale spawning of fish of economic importance, but relatively few experiments directed toward pure biological information have been conducted. In the United States such work has been limited for the most part to small experimental lots of fish, as pointed out by Pickford and Atz (1957), who reviewed and discussed all the available literature on the use of pituitaries and other gonadotrophic materials. On the basis of this review and our work in this field. it appears that technical experimentation has far exceeded academic studies, largely because of the practical value that such techniques afford fish-culturists in the spawning of fish. Because a problem so intricate embraces many fields--endocrinology, anatomy, histology, biochemistry, behavior, limnology, fish culture, and others--more often than not the basic factors prerequisite for sound experimentation are not applied and may not be fully understood. For this reason, the literature contains reports of a number of experiments having little or no significance, either because the investigators lacked adequate understanding of the dynamic aspects of the problem or because circumstances did not permit them to perform to greater advantage.

Much additional information must be gained before we shall know the qualitative and quantitative differences in fish pituitaries at various times in the year and the response to these pituitaries of fish of different physiological condition, age, and development. At present, good bioassay methods for fish gonadotrophins are unknown. Witschi (1940) demonstrated that the luteinizing hormone (LH) could be relatively assayed by injecting the material in weaver finches. The method employed for follicle-stimulating hormone (FSH) in fish pituitary materials involves the cornification of the mouse vagina, but these tests have been questioned since the substances tested were contaminated with proteins and possibly other hormones. Until good methods are devised, rather crude bioassay of whole pituitaries and unpurified extracts must be made.

Some recent papers, however, report that chorionic gonadotrophin, which is commercially available, is an ovulating agent when injected into fish. Ramaswami and Sundararaj (1958) injected human chorionic gonadotrophin into the Indian catfish (Heteropneustes) to induce spawning. Sneed and Clemens (1959) injected a similar material to spawn the channel catfish (Ictalurus punctatus). Other workers also have successfully used similar products to spawn or relieve egg-bound fish (for details, see Pickford and Atz, 1957). These products, as produced by the pharmaceutical laboratories, are not only effective in fish, but are more uniformly active because they are produced under controlled conditions and undergo rigid control tests in mammals.

Differences in response of individual fish can best be explained on the basis of a variability in physiological development of the recipient fish (Sneed and Clemens 1959; Clemens and Sneed, unpublished 1/). The fact that at least some kinds of chorionic gonadotrophins are physiologically active in fish, whereas pituitaries of mammals have proved relatively unsuccessful (Pickford and Atz 1957: table 47), is biologically significant. Such information may arouse considerable speculation concerning the structure of hormones in relation to their physiological and chemical activity, the phylogenetic specificity of pituitary and pituitarylike substances from

1/ Clemens, H. P., and K. E. Sneed. The bioassay and use of pituitary materials in spawning warm-water fishes, with notes relative to fish-cultural practice. Manuscript.

the various taxonomic groups of vertebrates, and the qualitative and quantitative differences in the hormonal components (FSH-LH) of the many materials which possess gonadotrophic activity. Most of these questions have not been answered, though considerable basic research has been underway for many years by medical men and biochemists working with numerous species of mammals.

Many of the early investigations concerning the response of teleosts to the gonadotrophins of fish and other classes of vertebrates suggested that teleosts did not respond to materials from other classes. However, recent work (Pickford and Atz 1957: tables 46, 47, 48, and 49; Sneed and Clemens 1959; Clemens and Sneed, unpublished [2]) has indicated that perhaps there is less specificity than originally thought. In fact, the evidence against any specificity appears to be growing. Fish have been injected with gonadotrophins derived from practically all the classes of vertebrates, with both positive and negative results in each class. Owing to the great diversity in methods employed, the wide differences in gonadal development between the different species tested, along with the variability in the fish of the same test group, a close comparison of results is often difficult. For the same reasons, a single positive result in any category far outweighs any negative results, since procedures, materials, and the judgment of the investigator concerning the conditions of the experiment so greatly influence the data. In this connection, in spite of several contrary experiments, Pickford and Atz wrote (1957: 204):

> ... A reckoning of all the available data ... reveals that no clear-cut line can be drawn between the percent of positive reactions obtained within the class of bony fishes and those obtained in instances where the donor belonged to another class .... The data ... however, are not good enough to make such close comparisons significant. They do, nevertheless, show that no absolute biological specificity of vertebrate gonadotropin has been demonstrated. ...

Over the years, the "appearance" of gonadotrophic specificity has gradually declined. This leads us to predict that future work may demonstrate that specificity is due to contaminating proteins which cause immunological reactions, to differences in tissue response on the part of individuals, or to occurrence of the active chemical component (which may be the same in all vertebrates) in nature attached to protein molecules of different molecular size or chemical activity. Apparently, Pickford and Atz (1957: 207) were of the same opinion when they wrote:

> ... We believe that when the chemical structure of the vertebrate gonadotropins is finally revealed, certain physiologically active chemical groups will be found to run through all the classes and these will be associated with other parts, perhaps carrier proteins, that differ phylogenetically. Such differences will be rooted in species specificity and their magnitude will be roughly correlated with phylogeny.

Dr. Richard Payne of the Oklahoma School of Medicine has reported (in an oral communication) that in preliminary experiments in Oklahoma he has obtained from mammalian pituitaries an active fraction which has a molecular size much smaller than was originally reported for gonadotrophically active fractions; however, the molecular arrangement seems very unstable. If Payne can substantiate this idea by further experimentation, it may lead toward a verification of the above predictions. More work certainly needs to be done on this subject. Clemens and Sneed working on a fish-cultural problem, [2] obtained 21 interfamilial and 26 interspecific and intergeneric successful combinations of pituitary injections. Seven combinations failed or had low activity, and these involved carpsucker and drum--a fact that cannot be explained easily from either our data or those of other workers.

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[2] See footnote 1, page 110.

If new evidence continues to contradict the assumption of specificity, or if phylogenetic differences are slight, then this information, coupled with the possibility that selected fish will respond to selected gonadotrophins from all classes of vertebrates, makes the fishes excellent test animals for the bioassay of gonadotrophins, regardless of source.

The study of gonadotrophins in fish has the advantage of contributing basic information that is applicable not only to this class but also to other classes. Thirty thousand species of fish offer an experimenter a wide choice of reproductive behaviors, morphological features, and environmental requirements. No other class of vertebrate can be cultured so easily and in such large numbers at such low cost. Large numbers permit a better analysis of the biological variability, as statistical methods can be applied. In most species of fish, a complete reproductive cycle is not crowded into days, weeks, or months, but is usually an annual event. This extended cycle may appear disadvantageous at first, but there are numerous advantages to be gained in fitting the kinds and amounts of dosages to the slowed-up reproductive cycle of fish. If there is a critical time for injection of a specific kind and amount of hormone, or if subtle responses are to be observed, it seems that these are more likely to be discovered in animals with the longer cycles. For these reasons, their use should be greatly expanded, not only to acquire additional information concerning fish and fish culture, but in order to provide a cheap, simple shortcut to the answers to many biological and clinical problems facing pharmacologists, biochemists, and physicians. In this connection, it may be mentioned that, with the proper selection of species, any positive reaction from hormone injections in fish is usually ascertained easily--that is, by visual observation of ovulated eggs, increased ovarian or testicular weight, nuptial coloration, spawning activity, and other features--and does not often require histological techniques as in mammalian work. Also, there is no concrete evidence, at the moment, for an assumption that the hormones and the ovarian and testicular cycle in teleosts are different from those in mammals, avians, amphibians, etc. It is true that some of the hormones of mammals have not been identified in fish or their function has not been demonstrated, but the lack of information undoubtedly is due to the paucity of investigations in this field rather than to the nonexistence of the hormones.

Although our present meager knowledge of fish gonadotrophins has led to a few techniques of importance in the culture of some species of fish, future progress seems likely to bog down for lack of basic biological data. Many fundamental problems are posed in the literature, and many questions go unanswered. That there is a need for more academic studies appears to have been recognized in some quarters, but the "practical" approach in solving some fish-cultural problems still takes precedence. However, it seems that the practical approach, although easily sold to those who support such investigations, is not the shortest means to the end, as its method is hit-or-miss experimentation that gives information of limited application--if information is forthcoming at all. The future attack by the government agencies concerned and our universities should be directed toward basic data.

Some of the biological data which are needed immediately and are applicable to the interests of both fishery biologists and the medical profession are obviously revealed by the literature and the foregoing discussion. For example, we know little about the gonadotrophic components of fish pituitaries or their relationship to gonadotrophins of other vertebrates. There is some evidence that an interstitial-cell-stimulating hormone (ICSH or LH) exists in fish. Carlisle (reported by Pickford and Atz, 1957) used chorionic gonadotrophin to relieve egg-bound fish, and later Ramaswami and Sundararaj (1958) and Ramaswami and Lakshman (1958) spawned the Indian catfish with injections of chorionic gonadotrophin--which, according to current opinions, usually acts as ICSH, but sometimes as ICSH and FSH, i.e., as

a complete gonadotrophin. Sneed and Clemens (1959) ovulated goldfish and spawned 3 pairs of white crappie and 39 pairs of channel catfish with human chorionic gonadotrophin. There appears to be a stage in physiological development of the gonads when these fish respond to hormone injections. If this is true, perhaps there is a period in the ovarian cycle that involves a follicle-stimulating hormone which promotes growth and development of the follicles. No investigator, however, has succeeded in obtaining the long-term growth of oocytes from a completely immature condition to full size and maturity by means of pituitary injections, although a few have accelerated the growth of ova by this means (Pickford and Atz 1957). The effect of such mammalian gonadotrophins as FSH and LH needs to be investigated further by injecting these, alone and in combination, into fish, especially hypophysectomized fish. In this connection, fractionation of pituitaries should be conducted in an attempt to isolate gonadotrophic components. If purified gonadotrophically active components can be successfully isolated from fish pituitaries, the door will be opened for identification of their chemical structure and specific effects on fish. Such information will hasten the day when we can control completely the reproductive cycle and perhaps the behavior, growth, and other features of beneficial fish. Robertson and Rinfret (1959) have successfully fractionated and administered in cholesterol pellets a fish pituitary preparation that brought about full maturity of the testes of young trout. Clemens and Sneed (not previously reported) have used this method of fractionation to obtain a preparation that induced ovulation and earlier spawning in a few preliminary experiments. Fractions obtained by this method conceivably could be used to stimulate oocyte growth and development in immature fish.

Other avenues of research which undoubtedly will yield valuable information for both fish-cultural and medical fields include the testing of materials which may act as hormones or as synergistic agents when combined with hormones. Agents which logically might be used are thyroid-stimulating hormones, growth hormone, estrogen, and androgens (several of which have already been used by Ramaswami and Lakshman (1958) and found to be ovulating or synergistic agents), trace elements, and all other hormones and hormonelike substances that have proved active in fish or other vertebrates. Also, we should investigate the effects of certain environmental factors which produce stress or may otherwise stimulate the intact fish to produce the hormones necessary to control a specific behavior in keeping with the wishes of man.

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"SUNBURNING" FINGERLING LAKE TROUT WITH ULTRA-VIOLET LIGHT AND THE EFFECT OF A NIACIN-FORTIFIED DIET

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FOR A NUMBER OF YEARS an abnormality has been observed among fingerling lake trout (Salvelinus namaycush) at the State Fish Hatchery at Marquette, Michigan. Each year, early in June, a "bald" spot begins to appear on the top of the head of fish in their second summer of life. The fish are held indoors in troughs during their first year of life and are transferred to outdoor raceways when they are about 1 year old. The "bald" appearance is caused by partial or complete erosion of the skin, exposing the light-colored bones of the skull. By the end of July approximately 20 percent of the fish are affected, but in August the condition begins to disappear, and by the end of September the lesions are completely healed. Mortality is above normal, although not high, and growth is retarded to some extent. Similar lesions have never been observed among older fish at this station.

Lesions similar to those in the lake trout fingerlings at Marquette were described by DeLong, Halver, and Yasutake (1958) among chinook salmon in Idaho; and by Dunbar (1959), who used a sunlamp to produce the symptoms among fingerling rainbow trout fed a standard diet at the Leetown National Fish Hatchery at Kearneysville, West Virginia. In both reports, the condition was termed "sunburn."

To induce sunburn, DeLong, Halver, and Yasutake (1958) exposed the fish to natural sunlight for 30 days and fed a diet deficient in niacin. They then divided the fish into equal groups: one group received the niacin-deficient diet, and the other received a complete diet. Mortality within 14 days after the fish were divided amounted to 15 of 83 fish on the deficient diet and 5 of 82 fish on the complete diet. There was no subsequent mortality in either group. According to our experience with lake trout fingerlings at Marquette, the condition clears up naturally during the late summer and fall months when there is less sunlight. DeLong and his cowriters (1958) did not report the time of year at which their observations were made, but the occurrence of shorter days may explain the arrested mortalities in their study.

To determine whether the "baldness" in lake trout at Marquette may have been caused by sunlight, 1-year-old fingerlings were brought to the pathologist's laboratory in Grayling and exposed for varying periods of time to light from a sunlamp positioned at various distances above the aquarium. Since DeLong (op. cit. 1958) found that mortality among fish fed a diet deficient in niacin was higher than among those fed a complete diet, as much as eight times the normal daily requirement of niacin was added to the diet of one group of fish to determine whether sunburning could be prevented in this manner.

Materials and Methods

Two groups of 1-year-old fingerling lake trout were held in separate aquaria (29-gallon) as stock supplies for experimentation. One group was fed a diet of

beef liver; the other group was fed the same diet plus niacin. For exposure to ultra-violet light, fish were transferred into a smaller aquarium (5-gallon) set up in a water bath with a constant temperature of 50° F. As fish fed different diets were exposed to the light at the same time in the same aquarium, they were fin-clipped for identification. Because the tests extended about 10 days and the fish refused food while they were held in the test aquarium, both groups were transferred to separate larger aquaria when not being exposed to the light.

Over the test aquarium one Westinghouse 275-watt RS sunlamp was suspended on a cord which permitted up-and-down adjustment of the bulb. The lamp was connected to a timing device so that it would turn on and off automatically at the same times each day.

The first test was made between April 15 and 19, 1959, to determine whether the sunlamp would induce symptoms of sunburn on the fish. The lamp was positioned 16.5 inches above the aquarium, which was filled with water to a depth of 4.5 inches. Daily periods of exposure to the light ranged from 9 to 12 hours. After a total of 25 hours of exposure to ultra-violet light, all fish had developed sunburn symptoms, but four of the five fish died. In the second test, May 8 to 13, 1959, the lamp was raised to 18 inches above the aquarium and the depth of the water was increased to 6 inches. Daily exposure to light was adjusted to 8 hours. After a total of 26 hours of exposure, all fish exhibited symptoms of sunburn, but two of the three test fish died. Niacin was not employed in either of these tests. The third and fourth tests were made between May 13 and June 8, 1959, with the lamp 19.5 inches above the aquarium filled with water to a depth of 6 inches. Daily exposure was 4 hours, and total exposure was 28 hours. Symptoms of sunburn developed, and there was no mortality. Both tests included two groups of three fish each, and one group in each test received the normal daily requirement of niacin added to the diet. Phillips and Brockway (1949) established the daily requirement of niacin for trout to be 3.0 to 4.1 milligrams per kilogram of fish. The greater amount was used in these tests.

The fifth and sixth tests were made between June 8 and July 30, 1959, under the same conditions as the previous two tests, except that daily exposure was 6 hours and total exposure was increased to 60 hours. No mortality occurred. The amount of niacin used was increased in the fifth test to four times the daily requirement, and in the sixth test to eight times the daily requirement.

Niacin was added to the diet from 1 to 3 weeks before each test, during each test, and for at least 2 weeks after each test.

Results

Definite symptoms of sunburn were produced in all groups of fish by exposure to ultra-violet light from the sunlamp. Because fish were killed (apparently by overexposure to the sunlamp) before sunburn symptoms developed into typical skin erosion, it is assumed that the light from the sunlamp was more intense than natural sunlight. The addition of niacin to the diet did not prevent the appearance of symptoms of sunburn, although the symptoms did not appear so quickly even among the fish that were fed the single daily requirement. On fish fed eight times the normal daily requirement of niacin, symptoms did not appear until about 18 hours after they were noted on the control fish; and the symptoms appearing on the fish fed this amount of niacin disappeared more quickly than the symptoms on the control fish.

Discussion

DeLong, Halver, and Yasutake (1958) demonstrated that niacin added to a niacin-deficient diet was effective in reducing mortality among fish exposed to natural sunlight. It might be assumed, then, that a niacin-fortified diet might prevent sunburn in trout. However, DeLong and his cowriters did not discuss the study by Phillips and Brockway (1949), who found that maximum storage of niacin in the liver of trout is attained when the trout

receives the daily requirement of this vitamin. Any additional amount is excreted in the urine and is of no benefit to the fish. The tests with a niacin-fortified diet reported here support the studies of Phillips and Brockway and show that little is to be gained by supplementing a diet already containing the daily requirement of the vitamin. Niacin supplements to diets should therefore be considered only when evidence indicates that a niacin or tryptophan deficiency exists, as nicotinic acid can be effective in lowering the tendency toward sunburn only when the fish are niacin- or tryptophan-deficient.

The assumption that a niacin-rich diet might prevent sunburn in lake trout fingerlings exposed to natural sunlight was tested in a limited experiment conducted during July 1958 at the State Fish Hatchery at Marquette. Three raceways containing equal numbers of lake trout fingerlings in their second summer of life were used in the experiment. About two-thirds of one raceway was shaded with specially constructed covers as a protection from sunlight, and the fish were fed the usual diet. Fish in the second raceway received food enriched by niacin at the rate of 5.8 milligrams per kilogram of fish per day. Fish in the third raceway were used as the control group, receiving no shade and fed a standard diet. Mr. Robertson, superintendent of the station, made observations reported here. Mortality in the 3-week period totaled 122 among fish fed niacin, 77 among fish in the shaded raceway, and 37 among the control fish. Mr. Robertson reported that during this period the sunburn lesions appeared to become gradually less conspicuous in all three groups. The test is not conclusive, in that no replicates are available for comparison and the actual number of fish with lesions was not recorded before and after the test. Daily observations revealed that fish in the shaded raceway hid under the covers when disturbed but did not seek the covers when not disturbed. Older lake trout appear to use covers to escape bright sunlight as well as for protection. This may be why the cover provided was not effective in reducing sunburn lesions among the younger fish. In 1958, several groups of fingerling lake trout were held throughout the summer in cement tanks in the hatchery building at Marquette, where they were completely protected from direct sunlight. None of these fish developed symptoms of sunburn. Fish of the same age that were held in outdoor raceways during the same period developed the symptoms.

Conclusions

These tests demonstrated that among fingerling lake trout fed a diet of beef liver, sunburn can be induced by ultraviolet light, and that the addition of niacin up to eight times the normal daily requirement will not prevent it.

Suitable raceway covers that completely shade the fish from direct sunlight should prevent sunburn. As the condition appears early in the year and regresses after the first of August, shade should be required only from May 15 to July 31. Water depth is 24 inches in the raceways where fingerling lake trout are held at Marquette. It is possible that deeper water would also be effective in preventing sunburn.

Acknowledgments

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LOW CONCENTRATIONS OF CALCIUM HYPOCHLORITE AS A FISH AND TADPOLE POISON APPLICABLE FOR USE IN PARTLY DRAINED PONDS AND OTHER SMALL BODIES OF WATER

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THE ESTABLISHED FISH-CULTURAL PRACTICE of removing fish and tadpoles from hatchery ponds makes it desirable to evaluate various substances for use in this work. The present study was designed to evaluate calcium hypochlorite ($Ca(OCl)_2\ 4H_2O$).

Calcium hypochlorite is widely available. It is a granular substance, relatively easy to handle and store. When dissolved in water, it produces 30 percent of its weight in gaseous chlorine. The fish-culturist is quite familiar with the use of chlorine and chlorine compounds as germicidal agents, but little information is available on the use of chlorine at lower concentrations as a fish and tadpole poison.

Materials and Methods

Toxicity tests were made in glass aquaria, 14 inches long, 8 inches wide, and 10 inches deep. Ten liters of water were used to make the diluents. Both hot tap water and pond water were used for the experiments. Whenever possible, the pond water was taken from the same pond as the fish. Before being used, the hot tap water was cooled to room temperature and aerated by compressed air. Hot water was used because, unlike cold tap water, it was found to be free of chlorine.

Four species of fish and one species of tadpole were used in the tests. The fishes included the green sunfish (Lepomis cyanellus), goldfish (Carassius auratus), black bullhead (Ictalurus melas), and golden shiner (Notemigonus crysoleucas). The tadpole used was Rana catesbiana. All the animals were kept in large holding tanks receiving dechlorinated and aerated tap water or aerated pond water. The animals were acclimatized to laboratory conditions before being used in the tests. The fish were fed canned horse meat until 2 days before their use. No food was given during the test period. A uniform temperature of 70° to 75° F. was maintained throughout the experiments, with the exception of certain tests that were purposely conducted at low temperatures.

The amount of calcium hypochlorite required to give a desired concentration was weighed and added directly to the experimental water. The actual amount of available chlorine produced by dissociation was determined by titration.

The chlorine determination was made at the beginning of each experiment, and residual chlorine was determined at odd intervals throughout the test periods. The temperature and pH were recorded at the beginning of each experiment. The pH was determined colorimetrically. Selected healthy animals were placed in the aquarium containing the desired concentration of calcium hypochlorite.

The introduction of the animals was considered as the beginning of the test period. Continuous observations were made for the first 2 hours, and periodic

observations were made afterward. Usually the experiments were terminated at the end of 48 hours, unless complete mortality occurred earlier. Test solutions were not aerated artificially for any of the laboratory experiments, but appropriate controls were maintained, and there was no mortality in the controls during the experiments.

Results

Both pond water and tap water were used in the experiments with the green sunfish. A study of the table will show that values of available chlorine were a little lower in pond water than in tap water. This may have been due to organic materials in pond water. The toxicity of calcium hypochlorite seemed to be greater in pond water than in tap water. At a concentration of 16.0 p. p. m. of calcium hypochlorite (available chlorine, 2.7 p. p. m.), 100 percent mortality occurred within 4 hours in pond water; but the fish survived up to 11 hours at the same concentration (available chlorine, 5.0 p. p. m.) in tap water. At 12.0 p. p. m. of calcium hypochlorite (available chlorine, 2.4 p. p. m.), total mortality of tadpoles occurred in

EFFECT OF VARIOUS CONCENTRATIONS OF CALCIUM HYPOCHLORITE ON BULLFROG TADPOLES AND REPRESENTATIVE FISHES

Calcium hypochlorite (p.p.m.)	Available chlorine (p.p.m.)	Type of water	Number of animals	Time (hours)	pH	Mortality (percent)	Temperature (° F.)
			Green sunfish				
6	2.0	Pond	3	48	7.0	0	72
9	3.0	Tap	7	24	7.0	28.6	76
10	2.0	Tap	5	24	7.2	60	74
12	3.6	Pond	5	24	7.0	100	72
15	3.8	Pond	5	24	7.5	100	73
18	4.0	Pond	3	10	7.6	100	74
18	3.7	Pond	3	24	7.6	100	73
21	4.7	Pond	5	24	7.6	100	76
			Golden shiners				
3	0.8	Tap	10	4.0	7.5	100	72
6	2.0	Tap	10	2.0	7.4	100	72
9	2.4	Tap	10	.6	7.2	100	72
			Goldfish				
3	1.6	Tap	5	4	7.0	100	75
6	2.8	Tap	5	3	7.2	100	74
9	3.0	Tap	5	2	7.2	100	72
12	3.9	Tap	5	3	7.4	100	72
12	4.0	Tap	5	1.5	7.5	100	75
16	5.2	Tap	5	2	7.6	100	72
19	6.0	Tap	5	1	7.5	100	75
			Black bullheads				
6	2.0	Tap	5	48	7.2	0	70
9	3.0	Tap	5	48	7.0	20	70
12	4.0	Tap	5	24	7.0	0	70
16	5.0	Tap	5	24	7.2	100	74

EFFECT OF VARIOUS CONCENTRATIONS OF CALCIUM HYPOCHLORITE ON BULLFROG TADPOLES AND REPRESENTATIVE FISHES--Continued

Calcium hypochlorite (p.p.m.)	Available chlorine (p.p.m.)	Type of water	Number of animals	Time (hours)	pH	Mortality (percent)	Temperature (° F.)
			Tadpoles				
6	1.2	Tap	5	48	6.7	0	65
9	2.6	Tap	10	24	7.3	0	72
12	3.8	Tap	10	48	8.1	0	70
12	2.4	Pond	10	8.5	7.6	100	67
12	3.9	Tap	10	48	7.5	80	45
16	5.0	Tap	10	48	7.6	90	45
16	2.7	Pond	10	4	8.2	100	65
16	5.0	Tap	10	11	8.1	100	70

pond water in 8.5 hours; but the tadpoles survived up to 48 hours at the same concentration in tap water (available chlorine, 3.8 p.p.m.). This apparent increase in toxicity may have been due to combination of the free chlorine with less toxic compounds in pond water to form comparatively more toxic compounds such as cyanogen chloride and chloramine.

Ten golden shiners were subjected to various concentrations in experiments using tap water. Total lengths of these fish ranged from 3 to 4 inches. Golden shiners were found to be more susceptible to calcium hypochlorite than other fish species studied. At a concentration of 3.0 p.p.m. of calcium hypochlorite (available chlorine, 0.8 p.p.m.), all the fish were killed within 4 hours of exposure; at 9.0 p.p.m. of calcium hypochlorite (available chlorine, 2.4 p.p.m.), total mortality occurred in 40 minutes.

Five goldfish were used in each experiment involving tap water. Total lengths ranged from 3.5 to 4.5 inches. In 3.0 p.p.m. of calcium hypochlorite, a 100-percent mortality occurred in 4 hours; in 19.0 p.p.m. of calcium hypochlorite (available chlorine, 6.0 p.p.m.), all the fish were killed in an hour.

Five bullheads were used for each concentration tested. Low concentrations of calcium hypochlorite had no effect on the bullheads. At 12.0 p.p.m. of calcium hypochlorite (4.0 p.p.m. of available chlorine), they survived for 24 hours. At 16.0 p.p.m. of calcium hypochlorite (5.0 p.p.m. of available chlorine), complete mortality was obtained in 24 hours.

Ten 2.5- to 3.5-inch tadpoles were used for testing each concentration. They are fairly resistant to chlorine. At a concentration of 16.0 p.p.m. of calcium hypochlorite (available chlorine, 5.0 p.p.m.), 100 percent mortality occurred within 4 hours of exposure at normal temperatures, whereas 90 percent mortality was obtained in 48 hours at a lower temperature. At 12.0 p.p.m. of calcium hypochlorite (available chlorine, 2.4 p.p.m.), all the tadpoles were killed in 8.5 hours at normal temperature, whereas some of them survived after 48 hours of exposure at a lower temperature. A rapidity in the onset of poisoning effect is noted at low temperatures, but the overall toxic effect is less than at higher temperatures.

Attempts were made to revive fish that had succumbed to various concentrations of calcium hypochlorite. At the time of loss of equilibrium, fish were transferred to fresh water. They failed to revive, but breathing movements continued for some time.

Calcium hypochlorite is very effective for the total removal of fish populations when it is used at a concentration of 16.0 p.p.m. of a hypochlorite compound that

yields 30 percent gaseous chlorine. This concentration results in 5.0 p.p.m. of available chlorine. As calcium hypochlorite is available commercially in different concentrations, the dosage must be calculated on the basis of available chlorine. The toxicity of chlorine does not last more than 2 or 3 days. This makes the restocking of the ponds possible with little loss of time.

On the basis of the strength of the materials available and 1958 prices, the cost of poisoning 1,000 cubic feet of water is approximately 90 cents. This high cost limits its use to small areas of water. Its most valuable application would be for ponds that have been drawn down.

Acknowledgments

I wish to acknowledge use of facilities made available at the Cooperative Fishery Research Laboratory of Southern Illinois University, Carbondale, Illinois. For his frequent advice and encouragement, I am deeply indebted to Dr. William M. Lewis, under whose direction this study was conducted.

A FEEDING DEVICE FOR FISH-CONDITIONING EXPERIMENTS

In fish studies that involve feeding as a conditioning stimulus, the fish must be fed without presenting visual cues. The device described here makes this possible.

Two 3/4-inch shutoff valves and a 3/4-inch tee connector with cap, placed as in figure 1, are set in the supply hose of the aquarium. To feed the fish, the valves are shut, the cap is taken off the tee, the food is inserted, the cap is replaced, and then both valves are reopened. Water pressure forces the food from the tee, through the second valve, and into the aquarium.

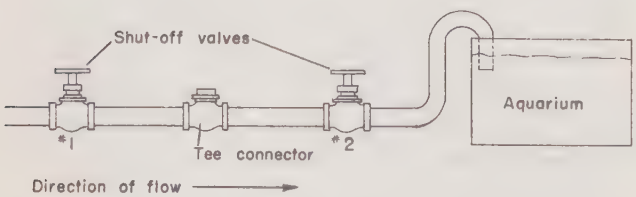

FIGURE 1.--Components of the feeding device.

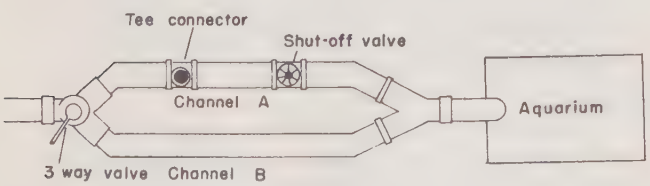

FIGURE 2.--The modified feeding device.

The size of these fittings may be varied according to diameter of the supply hose, size of the aquarium, or number of fish to be fed. To prevent clogging, however, the fittings should be at least 1/2 inch in inside diameter. The first valve's function is to stop the flow of water while food is being put into the tee connector. If the device is installed below the water level in the aquarium, and the supply-hose outlet is submerged, the second valve prevents the syphoning of water from the aquarium when the tee-connector cap is removed; if the hose outlet is above the water level, the valve keeps water from draining back through the hose when the tee-connector cap is removed. This second valve is not needed where the device can be set above the water level in the aquarium.

If desired, an uninterrupted water flow may be obtained by using the setup in figure 2. Water is bypassed into channel B while the shutoff valve is closed and the cap is off the tee connector. When the tee has been filled with food, water should be added until it overflows before the cap is replaced. This will keep air from being trapped in channel A. The shutoff valve is then reopened and the 3-way valve turned so that water is diverted into channel A.

--JOHN R. PUGH, Bureau of Commercial Fisheries, Seattle, Washington.

BIOLOGICAL NOTES ON PRECOCIOUS MALE CHINOOK SALMON PARR IN THE SALMON RIVER DRAINAGE, IDAHO

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PRECOCIOUS SEXUAL MATURITY in male chinook salmon (Oncorhynchus tshawytscha) parr has been recognized since at least 1902 in the Sacramento River in California (Rutter 1904). The phenomenon is established in many hatchery populations, but little has been published about its occurrence in a natural habitat. During 1958, as a supplement to other projects on the Salmon River drainage, information on the habits and natural history of these unique fish was gathered.

Distribution

Precocious development in juvenile males has been observed in most of the major tributaries of the Salmon River, waters which encompass a wide variety of environmental conditions. Streams in which these fish have been collected are the South Fork of the Salmon, Camas Creek, Elk Creek, Marsh Creek, Lemhi River, Hayden Creek, Herd Creek, and the headwaters of the Salmon River. This wide distribution suggests that precocity probably exists in all chinook salmon runs throughout the Salmon River drainage.

Age Classes

Examination of 3,443 salmon fingerlings from the Lemhi River showed that precocious development was prevalent in 2.6 percent of the sample. In a sample of 1,020 fingerlings collected on July 28, 1958, precocious young-of-the-year fish comprised 0.9 percent and yearling fish comprised 0.2 percent of the total. Actual percentages in the male population would be considerably higher, as the samples consisted of both juvenile males and females. Studies made on the Lemhi River during 1957 and 1958 indicated that all of the yearling chinook salmon found in the drainage after high water in June were precocious males.[1/] Figure 1 shows the relative sizes of normal fingerlings and precocious males.

Pre-Spawning Period

Gonad development in the young-of-the-year males in the Lemhi River is complete in 5 months from the time the fish emerge from the gravel. Fish collected on July 28, 1958, were nearly ripe.

Gonad development in yearling fish is already far advanced by June, and the fish are easily recognized by their deep bodies and swollen abdomens. On the upper Lemhi River in 1958, yearling males mistaken for trout were checked in fishermen's creels and often comprised nearly 25 percent of the catch.

Spawning Period

Observations during August 1958 on salmon spawning grounds in Marsh Creek

[1/] Gebhards, Stacy V. The effects of irrigation on the natural production of chinook salmon (Oncorhynchus tshawytscha) in the Lemhi River, Idaho. M.S. thesis, Utah State University, Logan, Utah. 1959.

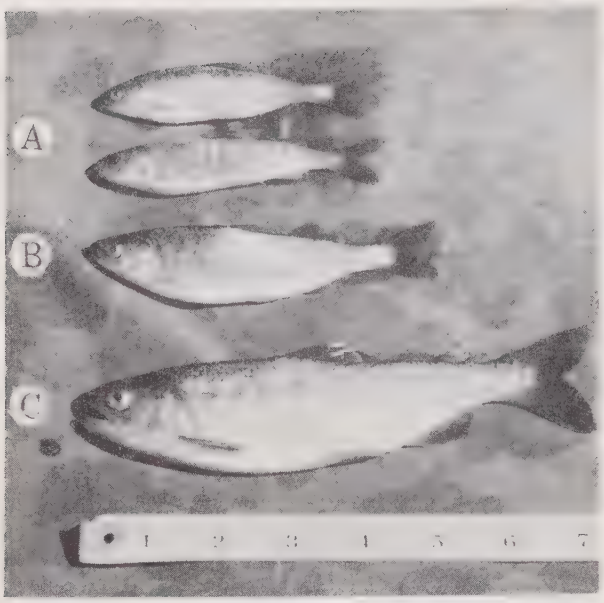

FIGURE 1.--Chinook salmon parr: (A) normal young-of-the-year, (B) precocious young-of-the-year male, (C) precocious yearling male. Collected in July 1958 on the Lemhi River.

and Elk Creek (headwaters of the Middle Fork of the Salmon) revealed the presence of large numbers of precocious yearling males. Generally they were found only in areas where there was active spawning. From 4 to 30 yearling males could be counted in a compact school lying in a redd. Often they would be with an adult female or with both the adult male and the female. Though an adult male would frequently move in and out of the redd, the yearling males remained constantly within the redd. Their position was usually in the pot of the redd, upstream from the tailspill. Occasionally an adult male would cause them to scatter, but they would quickly return to their original position. A sample of 49 yearling males found dead on the spawning grounds contained 21 fish that had been killed by an adult fish, probably a male.

Juvenile males which appeared to have died of natural causes were examined to determine the condition of the testes. Of these, 14.9 percent were unspawned, 48.1 percent were partly spent, and 37 percent were completely spent (figure 2).

The stomach contents of 40 yearling males were analyzed to determine their feeding habits during the spawning period. Of these stomachs, 75 percent (30 fish) were empty, 20 percent (8 fish) contained only insects, 2.5 percent (1 fish) contained a salmon egg and insects, and 2.5 percent (1 fish) contained a single salmon egg.

Post-Spawning Period

Post-spawning death of adult male salmon generally occurs within a week or 10 days after completion of the spawning act. Robertson (1957) found that precocious salmon parr, less than a year old, not only lived for 5 months after being stripped of their milt, but had exhibited a renewal of spermatogenesis. The survival of young-of-the-year males under natural conditions after the spawning act is not known. However, the fact that very few are found dead on the spawning grounds during and after the spawning season would indicate that the majority of the young-of-the-year males do not die after spawning. Only two of these fish were found dead on the spawning grounds in 1958. Both appeared to have died as a result of spawning; one was partly spent and the other was completely spent.

FIGURE 2.--A spawned-out precocious yearling male chinook salmon. Collected in August 1958 on Elk Creek.

The fate of the yearling males after spawning appears to be the same as that of the adult males. Trapping of downstream migrants on the Lemhi River during 1957 and 1958 failed to collect any yearling males after the spawning season. Examination of scales of 104 male salmon parr did not reveal any fish with more than 1 annulus. Thus it may be concluded that these yearlings die after spawning. Many of these fish exhibit the same loss of energy and the same physical appearance as spawned-out adult males, having eroded fins, patches of fungus, loss of mucous film, and sunken abdomen.

Examination of scale samples did not reveal any absorption at the periphery of the scale in either age class, and no spawning checks were apparent in the yearling fish.

Discussion

A question arises whether young-of-the-year males which mature sexually survive the spawning act and spawn again the following year. Robertson's studies on hatchery fish substantiate this probability. The difference in the percentages of occurrence of the two age classes found on the Lemhi River (0.9 percent young-of-the-year males and 0.2 percent yearling males) may reflect the natural mortality and limited spawning mortality between the first and second years of life. It is also possible that the young-of-the-year males migrate to the ocean after the spawning season, and that the yearling males mature sexually only in their second summer.

Observations of the activities of these salmon on the spawning grounds suggest that they may perform the same function as the adult male in fertilizing the eggs. Robertson (1957) and other workers have found that sperm produced by precocious male salmon parr is viable. Frequently, adult males may be away from the female during the period in which she lays her eggs and covers them. As the precocious male parr are in constant attendance, they may play an important role in the fertilization of the eggs. Further study into the life history and genetics of these fish may show that they can partly substitute for the adult male and thereby allow a greater harvest of the adult males without reducing the spawning potential of the run.

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Rutter, Cloudsley
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The Salmon Cultural Laboratory of the Bureau of Sport Fisheries and Wildlife, at Entiat, Washington, has concluded its experiments on methods for the acceleration of maturation. The survival of progeny of adult blueback salmon that had been subjected to controlled light (THE PROGRESSIVE FISH-CULTURIST 21 (2): 63-69) was compared with that of a controlled group. The total survival from eggs through the first 64 days of feeding was 1.2 percent higher in the accelerated group than in the control group. Although this difference in the survival is not considered significant, it is obvious that no deleterious effects can be attributed to acceleration of the maturation of the parent fish.

APPLICATIONS OF A BOAT-RIGGED DIRECT-CURRENT SHOCKER ON LAKES AND STREAMS IN WEST-CENTRAL WISCONSIN

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ONE OF THE PROBLEMS IN USING ALTERNATING CURRENT TO SAMPLE FISH POPULATIONS is that it is difficult to pick up fish from the bottom of a lake or stream after they are stunned. The efficiency of the shocker crew decreases in turbid waters and in densely vegetated areas because of poor visibility and consequent inability to collect stunned fish. The use of direct current seems to offer advantages.

The boat-rigged direct-current shocker described here is effective because the fish are attracted to a grid suspended just below the surface of the water. The unit was developed primarily for use as a sampling and cropping device in walleye rearing ponds. The original unit has been modified and used successfully under a variety of conditions. Fish populations in large streams and turbid lakes have been sampled successfully with this shocker. The boom shocker is effective on almost all species of fresh-water fish common to the Midwest.

A direct-current field usually is set up in water by approaching the fish with the anode so that they encounter the attracting side of the electrical field first. We have reversed this procedure and have the cathode precede the anode.

In clear lakes where reaction of fish to the electrical field can be observed, the majority of the fish exhibit little reaction to the cathode unless it passes within a few inches of them. Fish repelled by the electrical field are usually along its outside edge and to one side of it.

FIGURE 1.--Direct-current boom shocker in use.

We have observed the cathodes pass on either side of fish without apparent effect until they are slightly beyond the fish, at which time the fish will suddenly be attracted to the anode.

If a fish escapes momentarily, it can be chased and captured. Many times large fish are seen swimming between the shocker and the shoreline--and usually it is easy to turn the shocker and capture these fish. The mobility of the shocker and the large areas that can be covered in a relatively short time are definite advantages in sampling.

General Description

The direct-current boom shocker consists of three 12-foot hollow Fiberglas booms which are mounted to protrude 10 feet in front of a 16-foot flat-bottomed boat (figures 1 and 2). The paired support booms are attached to the gunwales of the boat. Two feet forward from the point of attachment, they are supported by a crosspiece which holds the terminal ends above the surface of the water. The cross boom is attached to the fore ends of the support booms, thereby making the entire unit more rigid. Three negative electrodes are suspended vertically and in line from the cross boom. The positive electrode is suspended from the support booms, about 5 feet behind the negative electrodes, and is hung so that it rides just under the surface of the water when the boat is in motion. Power for energizing the electrodes is supplied by a 230-volt direct-current generator. Motive power for the boat is an outboard or air motor.

Mechanical Components

Support booms are attached to the boat in the following manner: The butt of a glass boom (about 1.25 inches in diameter) is wrapped to a height of 16 inches with a piece of inner tube for protection. A 16-inch piece of conduit pipe (1.5 inches in diameter) is cut in half lengthwise. A hinge is welded to one end of the two pieces, which are held together in their original position. The wrapped portion of the boom is inserted into the split conduit. Automobile hose clamps are used to tighten the pipe around the boom. The unit is attached to the boat by means of a bolt (0.1875-inch) inserted through a hole in the hinge and the gunwale of the boat. A wood crosspiece giving further support to the support booms is attached to the boat 20 inches in front of the point of attachment of these booms. With both support booms attached in this manner, the cross boom is connected with the fore ends of the support booms by hose clamps.

Each negative electrode consists of two 3-foot lengths of rigid copper tubing (0.5 inch in diameter) joined by polyethylene tubing. A "jump" wire through the center of the polyethylene bridges the gap between the upper and lower sections. The polyethylene gives flexibility to the electrode and prevents weeds from clinging to

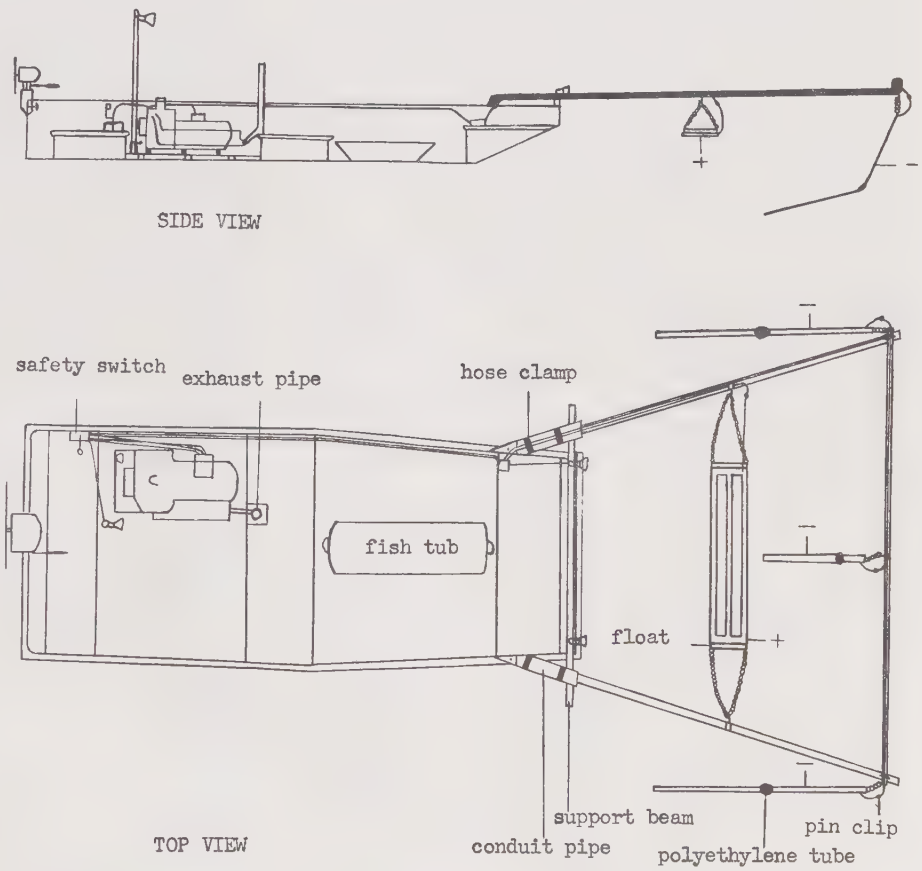

FIGURE 2.--Schematic diagram of a direct-current boom shocker.

the joint. An 8-inch piece of sash chain is attached to the upper end of each electrode. For mounting, the sash chains are hooked into metal snaps permanently attached to the cross boom, which permits rapid hanging and removal.

The positive grid is 15 inches wide and 61 inches long. It is composed of two lengths of copper tubing or stainless steel bent and joined by two T's to form a rectangle. A third piece is added in the center (lengthwise) to make a grid with three bars. Floats are attached at the sides of the grid to provide buoyancy. Twenty-four-inch lengths of galvanized sash chain are attached to the floats. The lengths of chain used will depend on the angle of the support boom. These chains are then attached to snaps located 5 feet from the fore ends of the support booms. The grid is hung so that it rides at a slight angle with the leading edge higher than the trailing edge. This permits the grid to pass more easily over dense vegetation without becoming fouled.

The generator is placed in front of the rear seat, on the left-hand side of the boat. The lead-out wires from the generator are connected to a fused Square D switchbox with a double-lock-plug receptacle attached to it. The box and receptacle are mounted on the rear seat of the boat. Conduit pipe (0.5-inch) mounted on the left side of the boat connects the fuse box to an identical double-lock-plug receptacle in the bow of the boat. All wiring circuits pass through this conduit. The circuit providing power for the electrodes is fused. If the electrodes short-circuit, a fuse will blow. If the operators wish to cut the power to the electrodes without stopping the generator, it can be done by breaking the circuit. Lock plugs and receptacles connect these wires to positive and negative wires in the left boom. Each wire has a different color to prevent confusion in circuit arrangements. The wires from all electrodes are provided with automobile-type pin clips. This facilitates breakdown for transportation purposes and allows quick interchange of various electrodes and electrode arrangements.

The light circuit is separate from the electrode circuit and is wired in series. This allows use of 115-volt light bulbs with a 230-volt power source. The two bow light holders are mounted on the wood support beam and can be turned in any direction. One light is mounted on a 7-foot mast which is placed in a holder back by the motor operator. This light is used to spot landmarks and to provide light for processing captured fish.

To disassemble the unit, the electrodes are removed and placed under the front seat of the boat. The hose clamps at the fore are loosened, and the cross boom is removed and put in the boat. The hinged support booms are lifted to an angle of 90°, twisted 180°, and then laid down in the boat. The entire procedure takes only a few minutes, and all components are neatly stowed in the seat.

Applications of the Shocker

This shocker unit was designed primarily to sample and crop walleye fingerlings in shallow, natural ponds; but it has been used also for lake and stream investigations. It was first tested in the spring of 1958 in natural rearing ponds that contained hold-over walleyes 8 to 14 inches in length. Four circuits around the perimeter of one 5-acre pond having a maximum depth of 5 feet yielded 39 fish. Subsequent treatment with rotenone produced 17 more fish. In a 6-acre pond that had a maximum depth of 4.5-feet, shocking produced approximately 1,000 walleyes averaging 8.5 inches in length. Subsequent treatment with rotenone produced 333 more fish. These results indicated that the shocker could be employed effectively on walleyes in shallow ponds.

Three ponds were sampled during the summer by seining with a 200-foot nylon seine (0.25-inch mesh) and with the direct-current boom shocker. These operations were carried on simultaneously during the daytime in comparable areas. The ponds were shallow, and we assumed that there was a random distribution of fish throughout the areas covered during the sampling operations. Many walleye fingerlings

TABLE 1.--The results of seining and shocking in walleye rearing ponds

Ponds	Pounds of fish	Fish per pound	Number of man-hours	Pounds of fish per man-hour	Methyl orange alkalinity	Pond area (acres)	Maximum depth (feet)	Average depth (feet)
Pond No. 1:								
Seine------	35	158	6.0	5.8	13	3.0	3.0	1.5
Shocker----	3	158	2.5	1.2				
Pond No. 2:								
Seine------	24	133	6.0	4.0	58	2.5	4.3	2.25
Shocker----	10.4	133	1.5	6.9				
Pond No. 3:								
Seine------	1.14	100	1.0	1.14	24	8.0	2.5	1.25
Shocker----	2	100	1.0	2.0				

were missed during the shocking runs in Pond No. 2. Walleye fingerlings were attracted to the grid in such large numbers that many were stunned and drifted away or sank before they could be captured. The seine was more effective than the shocker in the soft-water ponds, but the performance of the shocker improved in the medium hard-water pond (table 1). Ponds which were difficult to seine because of heavy growths of filamentous algae or submergent vegetation were easily sampled with a boom shocker.

Since the rearing-pond investigations, the direct-current boom shocker has been used on streams, rivers, and impoundments that were difficult to sample effectively in the past with standard netting gear. To indicate the effectiveness of the shocker, data obtained in shocking two ecologically different lakes are presented in table 2.

Lake No. 1, an impoundment, has a surface area of 455 acres, a maximum depth of 20 feet, and a Secchi-disk reading of 1.5 feet. It has large shoal areas and

TABLE 2.--The results of boom shocking in two ecologically different lakes

Species	Daytime shocking Lake No. 1 10 to 11:35 a.m.		Daytime shocking Lake No. 2 3 to 4 p.m.		Nighttime shocking Lake No. 2 8:30 to 9:30 p.m.	
	Number	Size range (inches)	Number	Size range (inches)	Number	Size range (inches)
Rainbow trout----	1	9	------	----------	------	----------
Largemouth bass--	29	2.1 - 12.1	15	2.5 - 7.2	195	5.0 - 16.8
Bluegill---------	53	2.8 - 6.8	25	1.6 - 5.8	99	2.1 - 8.5
Rock bass--------	------	----------	3	4.2 - 4.7	7	1.9 - 6.6
Green sunfish----	------	----------	11	3.0 - 4.7	119	2.6 - 4.7
Pumpkinseed------	2	3.7 - 4.5	7	3.7 - 5.6	12	3.7 - 6.0
Yellow perch-----	2	2.5	1	5.5	------	----------
White crappie----	16	6.5 - 8.0	------	----------	------	----------
White bass-------	1	6.5	------	----------	------	----------
Redhorse sucker--	10	6.5 - 18.3	------	----------	------	----------
Black bullhead---	1	7.0	------	----------	------	----------
Carp-------------	129	15.0 - 30.0	------	----------	------	----------
Total---------	244		62		432	

is usually turbid throughout the open-water season. Lake No. 2 is landlocked and has a surface area of 35 acres, a maximum depth of 58 feet, and a Secchi-disk reading of 14 feet. It has very little shoal area, and the water remains clear throughout the year. The methyl orange alkalinity of the two lakes is 122 and 120 parts per million, respectively.

It has been our experience that shocking is more effective at night than during the daytime in clear-water lakes, but there is not much difference in shallow turbid waters. It is also evident that boom shocking is effective on fish species which are net-shy (e.g., largemouth bass and carp).

The moderately swift Apple River, which has shallow densely vegetated areas, was shocked with the direct-current unit by floating downstream with the current. When a pool was reached, the boat was turned upstream and several runs up and down were taken through the pool. Warm- and cold-water species of fish were taken by this method.

It has been our experience that by varying the time of shocking to coincide with maximum abundance of fish in shallow waters, good results can be obtained in medium hard waters.

Fish caught in the electrical field swim up to the positive grid and hang there until they are stunned. They have been observed to follow a moving positive electrode for 20 seconds before becoming stunned and floating away. Fish of all sizes have been captured. The unit can can be used to sample reproduction or fingerling survival in shallow, weedy, stumpy areas where it is not feasible to seine or use other mechanical means of sampling. A two-man crew can cover a large area in a short time and sample various types of shallow-water habitat.

The unit described has been in use only one season and has been successful in its present stage of development, but there are undoubtedly modifications that can be made to increase its effectiveness.

Acknowledgments

The writer is indebted to John Brasch, Wisconsin Conservation Department, for reviewing this paper, and to his co-workers for helping to field-test this unit and suggesting modifications that increased its effectiveness. The glass booms used were donated by the St. Croix Company, Park Falls, Wisconsin.

A SURVEY OF FISHING IN 1,000 PONDS STOCKED BY THE BUREAU OF SPORT FISHERIES AND WILDLIFE

Willis King

Circular 86. Bureau of Sport Fisheries and Wildlife, Washington 25, D. C. 1960.

To evaluate its program of stocking farm and ranch ponds with fish produced at the national fish hatcheries, the Bureau of Sport Fisheries and Wildlife surveyed 1,000 ponds during December 1959 and January 1960. These ponds represented 2.5 percent of the ponds stocked in 1957.

Eighty-two percent of the ponds gave satisfactory or excellent fishing. Too many small bluegills, silt or muddy water, and wild fish were most often blamed for the unsatisfactory fishing in other ponds.

The ponds provided fishing at the rate of 64 fisherman-days per acre. The average catch was 54 bass and 276 bluegills and other sunfish per acre. Catfish, with bullheads, contributed to the fishing in 20 percent of the ponds.

Assuming a productive life of at least 5 years, and projecting the findings on 1,000 ponds to all those stocked by the Bureau, it was estimated that this program made 20 million man-days of fishing available to at least 5 million persons.

A COLLAPSIBLE NYLON FISH TRAP FOR POND SAMPLING

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A STANDARD FISH-COLLECTING GEAR used by Oklahoma fishery workers during the past decade has been the wire trap. Though many other forms of gear were also commonly in use, this trap has been preferred for use on ponds and small lakes. Most workers have agreed that this trap possessed several desirable characteristics not found in other types of gear. In the first place, this trap caught fish effectively. It was also economical to construct, easily repaired, and because it was rigid, nothing more than lowering the trap into the water was required to set it.

The wire trap was cylindrical in form and had throats on each end. It was 6 feet long and 3 feet in diameter. A welded steel framework of four longitudinal rods and three circular hoops served to maintain its rigid form. Galvanized-wire poultry netting (1-inch mesh) was used for cover material and for construction of its conical throats. A door was cut into the side for removing fish. A section of rope attached to the frame and to a wooden marker float provided a means of raising and lowering the trap.

Many criticisms have been offered by fishery workers, and the need for an improved design has been expressed by all for some time. Because of the rigid construction, the wire trap was difficult to transport. The weight of 30.5 pounds per trap was considered excessive, and the poultry netting normally had to be replaced every 3 months. Distortion in the shape of the trap commonly resulted from bent wire netting. Cut and broken wire ends caused injury to hands as well as wear and tear to the workers' clothing. Recently fishery workers have become more aware of the excessive injury to fish caused by the wire netting. Injured fish in mark-and-recapture population estimates were subject to higher mortalities than normal.

Recent advancements in the development of synthetic fibers which have superior qualities for use in fish nets provided an opportunity for the development of many new designs. The workers at the Oklahoma Fishery Research Laboratory have constructed and tested several new models of fish traps, using nylon for all webbing and lines in an attempt to improve the standard gear. The general configuration of the wire trap was maintained in the new models, but the 1-inch-mesh wire was replaced with 5/8-inch (square mesh) knotted nylon webbing. The steel framework was replaced with five spring-steel hoops. With these changes, the trap became collapsible. Detachable brails or spreaders were added to obtain a rigid form in the net when the trap was fished. The entire trap was then treated with a preservative for synthetic-fiber nets.

Results of Field Tests

The first model of the nylon trap that we constructed was 30 inches in diameter

Contribution No. 75 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma Biological Survey.

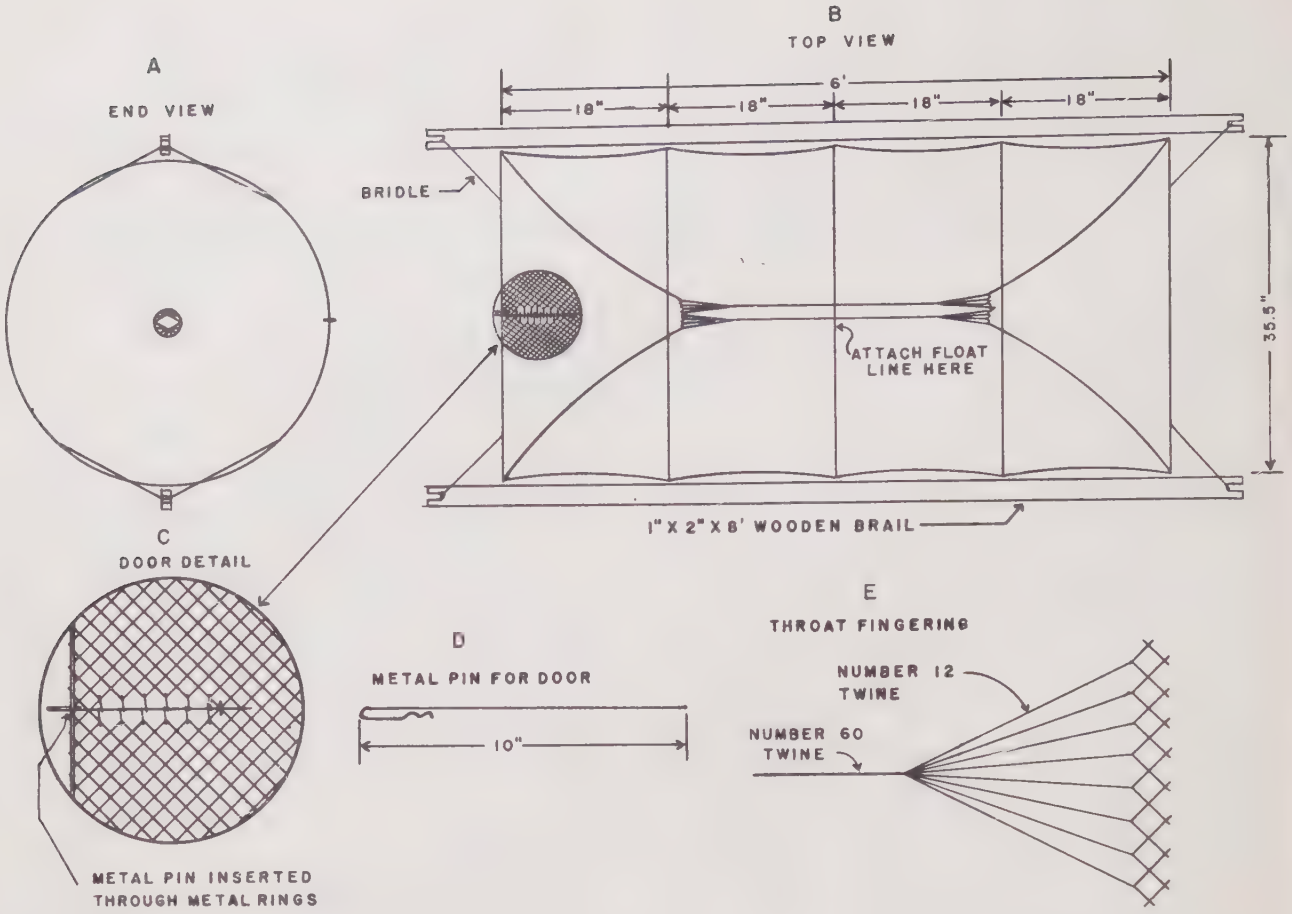

FIGURE 1.--Construction detail of trap. (A) End view. (B) Top view, showing position of throats, door, brails, bridles, and floatline. (C) Door detail. (D) Metal pin for closing door. (E) Fingers in throat.

and 6 feet long. Throat openings were approximately 4.5 inches in diameter, the same as in the wire models. As the wire trap had no fingers in the throat (figure 1) and we wished to duplicate its configuration, none were incorporated in the new trap. Except for diameters, the two were essentially alike.

In June and July 1959, a population estimate was made on Lake Louis Burtschi, a 160-acre lake in southwest Oklahoma, where this new model was first critically tested. In 265 trap lifts, the rate of catch per lift for the nylon trap was 3.9 fish; whereas in 379 lifts of the wire traps, the rate of catch was 16.5 fish. From these data it was apparent that further changes in design were needed. After closer examination of the trap it was concluded that the differences were most likely due to escapement. To correct this apparent fault, fingers were added to the throats, an addition which somewhat obscured the opening from an interior view (figure 1, E). Several new and larger traps with 35.5-inch diameters and fingers in the throats were also assembled.

A short-term comparative test was conducted during January 1960 in 27-acre Crystal Lake, near the laboratory. In this test three each of wire traps, 35.5-inch-diameter nylon traps with fingered throats, 30-inch nylon traps with fingered throats, and 30-inch nylon traps without fingered throats were fished. Analysis of the results obtained by adding fingers in

the smaller traps indicated that their catch was raised from 4.3 to 12.2 fish per lift, a 180-percent improvement (table 1). The 36-inch nylon trap caught 14.4 fish per lift. The 30-inch trap with throat fingers made a catch of 12.2 fish per lift; thus the 5.5-inch increase in diameter achieved an 18-percent increase in effectiveness. Both sizes of nylon traps with fingers made better catches than the wire traps, and an increase from 11.4 fish per lift for the wire to 14.4 for the larger nylon traps demonstrated an improvement of 26 percent.

The lower limit of the length range of fish captured by the 1-inch-mesh wire trap was extended considerably when the 5/8-inch-mesh nylon was substituted (table 2). Some of the increased efficiency of the nylon nets can be accounted for by this mesh selectivity. However, for some species it appears to operate more effectively throughout the length range.

TABLE 1.--Comparison of catch per lift for four different models of the cylindrical fish trap used in Crystal Lake

Species	36-inch wire, 1-inch mesh	35.5-inch nylon with throat fingers, 5/8-inch mesh	30-inch nylon with throat fingers, 5/8-inch mesh	30-inch nylon without throat fingers, 5/8-inch mesh
Largemouth bass--	0.4	0.4	--------	--------
Bluegill---------	3.1	11.1	10.1	1.7
Redear sunfish---	1.7	1.5	.9	1.7
Green sunfish----	-------	---------	.1	.1
Warmouth---------	.1	.1	.3	.1
Hybrid sunfish---	.9	.5	.6	.4
Golden shiner----	1.1	.2	--------	.1
Black bullhead---	4.0	.6	.2	.2
Channel catfish--	.1	---------	--------	--------
Average----------	11.4	14.4	12.2	4.3
Number of fish caught----	170	216	171	57
trap lifts-----	15	15	14	13

Construction Details for Nylon Trap

Dimensions: 6 feet in length, and 35.5 inches in diameter.

List of materials for one trap:

Webbing: 5/8-inch-mesh (square measure) knotted No. 9 nylon twine, 127-1/2 meshes deep, 123 meshes long, 2 pounds 12 ounces.

Twine: Approximately 1/4 pound of No. 9, 1/4 pound of No. 12, 6 feet of No. 60, and 20 feet of No. 120.

Rope: 20 feet of 1/4-inch nylon rope.

Marker float: 1, wood, 2" x 10" x 10".

Brails: 2, yellow pine, 1" x 2" x 8'.

Rings: 13 metal rings, approximately 1/2 inch in diameter.

Wire: 12 inches of No. 9 galvanized.

Hoop steel: 1/4-inch hoop-net spring steel, sufficient for 5 hoops (8 pounds), 35-1/2 inches in diameter.

Couplings: 5 hoop couplings of 1/4-inch I.D. steel pipe, 3 inches long.

Suggested Procedure for Construction

1. Use sheet nylon webbing exactly 127.5 meshes deep having a single selvage on both sides.

2. Cut five hoops from stock materials. Maintain diameters of 35.5 inches. Fit and secure a coupling on one end of open hoop.

3. From sheet webbing cut one piece of webbing 123 meshes long, sufficient material to make one trap.

4. As shown in figure 2, from the cut edges (not selvage) cut out and remove the triangular sections as waste.

5. Bring the two selvage edges together and tie, using standard weaver's knot, converting the web into a cylinder 128 meshes in circumference. Special attention should be given to matching corresponding meshes.

6. On each end of the cylinder of webbing, there are now four triangular cuts. Pull together and tie each of the adjacent cut edges from which triangles were cut. This will reduce the size of the opening

on the ends of the cylinder to 16 meshes. These openings form the funnel or throat opening to the trap.

7. To install hoops, thread a free end of hoop through the 26th mesh, counting from either throat opening, until it has encircled the cylinder of web. Pull ends of hoop together and couple. Clinch the coupling.

8. Moving down the length of the web, install four more hoops, using the same procedure except that spacing will be 17 meshes between hoops and hoops will be threaded in the 18th mesh. When all hoops have been installed, 25 meshes will extend beyond each end hoop to provide the material for throats.

9. Make two wood brails (figure 1, B).

10. Tie on bridles made of 120 nylon, and stretch net on brails.

11. Add fingering to the throat, and adjust tautness of throats (figure 1, B and E).

12. Make door for fish removal by cutting out webbing. Tie in 13 small metal rings to serve as eyes through which a metal pin can be inserted to close door of trap.

13. Make a metal pin from No. 9 galvanized wire for door closure (figure 1, D).

14. Cut a 20-foot section of 0.25-inch nylon rope and tie to center hoop on top or door side. Attach a marker float.

15. Treat entire net with preservative designed specifically for nets of nylon and other synthetic fibers.

The average cost of materials for constructing 13 of these traps was $20.90 per trap. The minimum time for construction was 4 hours, and labor costs averaged $8 per trap. Average cost for materials and labor placed the cost per trap at $28.90.

TABLE 2.--Comparison of length frequencies of bluegill and redear sunfish captured by 36-inch-diameter wire and nylon traps used in Crystal Lake

Length in inches	Redear sunfish		Bluegill	
	1-inch-mesh wire trap	5/8-inch-mesh nylon trap	1-inch-mesh wire trap	5/8-inch-mesh nylon trap
3.1	-------	---------	-------	3
3.3	-------	---------	-------	8
3.5	-------	2	-------	9
3.7	-------	2	-------	14
3.9	-------	---------	-------	17
4.1	-------	---------	1	16
4.3	-------	1	-------	14
4.5	1	---------	3	13
4.7	4	3	4	7
4.9	1	1	3	6
5.1	3	2	4	9
5.3	2	1	8	14
5.5	2	1	6	11
5.7	2	5	4	11
5.9	1	----------	4	8
6.1	4	1	3	3
6.3	-------	1	1	1
6.5	2	2	4	1
6.7	-------	---------	1	---------
6.9	3	1	1	---------
7.1	1	---------	-------	---------
8.3	-------	---------	-------	1
9.7	-------	---------	-------	1
Over 4 inches--	26	19	47	116
Total----------	26	23	47	167
Average total length-------	5.7	5.2	5.5	4.6

Discussion

In the short term in which these traps have been used, we have concluded that the collapsible nylon-net trap has some definite advantages over the old wire trap.

The breakdown feature, which permits greater ease in hauling, is singularly important. It was virtually impossible to haul wire traps in any motor vehicle other than a truck or pickup, but 30 or more of the new type can be neatly carried in a station wagon.

None of the new traps have been in existence long enough for us to evaluate their resistance to deterioration and general wear and tear; however, recent experience in the use of treated nylon for trap nets indicates that no visible damage can be expected for at least 2 years. Also, should some damage occur, repairs can be made easily with nylon twine.

Replacement of the wire with nylon webbing eliminated the danger of injury to hands and the inconvenience of torn clothing.

Injury to fish from the netting no longer occurs, and the rate of catch is greatly improved.

The new trap weighs only 18 pounds, which represents a weight reduction of approximately 40 percent.

The smaller mesh size of the web retains much smaller fish, a factor which also increases the length range of fish sampled.

Treating the nylon net with preservative protects it from damage by sunlight and stiffens the twine so that gilling of of fish is practically eliminated.

These advantages were deemed sufficient to warrant changing our standard gear for sampling ponds and small lakes from the wire to the nylon type described here.

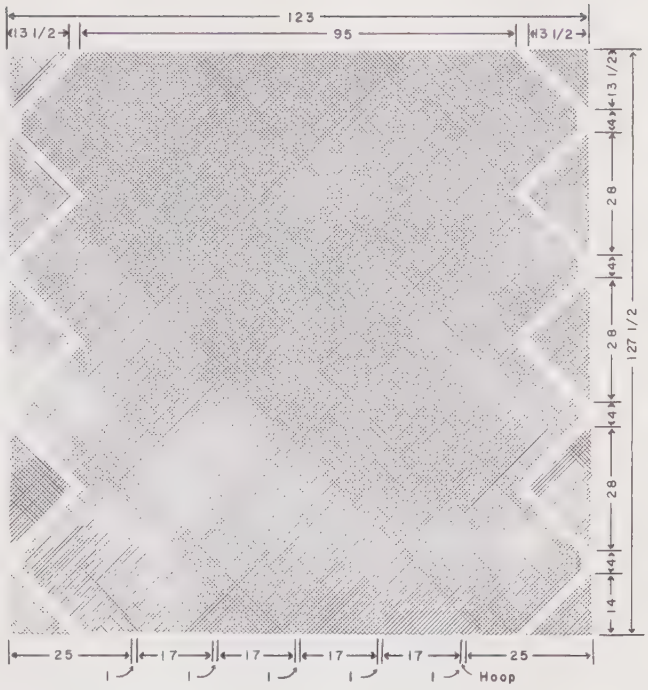

FIGURE 2.--Dimensions in meshes for cutting webbing to make one trap.

A SMALL BOAT WITH WHEELS

A small boat with delicately positioned wheels enables fishery workers to transport equipment along shallow streams.

Made of marine plywood or aluminum, this boat is 9 feet long, 30 inches wide, 15 inches deep, and has a steep rake at the forward end. Two wheelbarrow wheels with 4:00-8 tires (15-inch outside diameter) are mounted on a hard steel axle set high on the bottom of this forward rake.

This boat floats in as little as 3 inches of water and can be pulled--stern first, wheels under rake behind--over shallow riffles. Rather awkward for crossing high log jams and tight fences, it can be pulled over rough gravel with relative ease.

Aside from holding equipment, it provides a convenient place to work on fish.

--R. WELDON LARIMORE, Illinois Natural History Survey, Urbana, Illinois.

USE OF A SMALL OTTER TRAWL TO SAMPLE DEEP-WATER FISHES IN MAINE LAKES

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THE MAINE DEPARTMENT OF INLAND FISHERIES AND GAME has been hampered in its studies of the American smelt (Osmerus mordax), the lake trout (Cristivomer namaycush), and the blueback trout (Salvelinus oquossa) by the fact that the young of these species frequent the deep water of lakes during most of their first year and are difficult to sample. Nylon gill nets with mesh as small as one-fourth inch (bar measure) can be used, but results have proved inconsistent. A more reliable method of capturing small fish in deep water was needed. Use of a small otter trawl that could be towed by an outboard boat seemed promising.

Correspondence with personnel of the Bureau of Commercial Fisheries working at the Narragansett Marine Laboratory put us in contact with Mr. Stanley A. Spink, a boat captain, fisherman, and net builder then employed at the Narragansett laboratory. After discussing our fishing problem, Mr. Spink designed a small otter trawl and built us a prototype. The trawl currently being used in Maine (figures 1 and 2) has been evolved from Mr. Spink's original design.

This trawl, towed with a 14-foot open boat powered by a 10-horsepower outboard motor, has proved very effective in taking small deep-water fish. This includes young-of-the-year smelts, lake trout, and whitefish as well as sculpins, burbot, perch, suckers, and sticklebacks as small as 1 inch in length. The largest fish that has been taken in this trawl was a 19-inch lake trout. However, the capture of larger fish is not common; most larger individuals are apparently strong enough and fast enough to escape this gear.

The trawl may be towed with a warp as small as 1/4-inch manila, although a larger rope is easier to handle. The depth-to-warp-length ratio usually recommended is 1 : 5, but we have found that greater warp lengths generally give better results. Present policy is to use 500 feet of warp for all depths up to about 80 feet. We have not used the trawl in depths greater than 80 feet.

The trawl can be set most easily if there is a slight breeze and the course can be arranged to trawl downwind. The boat is turned sideways to the breeze, the motor is turned off, and the trawl and otter boards are put over the windward side. When the gear is hanging free 15 to 20 feet below and behind the drifting boat, the motor is started, the boat is turned downwind, and the rest of the warp is paid out with the motor running about half speed. When the warp is all out and secured, the motor is opened to full power. Full power with this gear gives a speed of 3 to 4 miles per hour.

To haul the trawl at the end of a trawling course, it is necessary to stop the boat and then pull the gear aboard. This is a definite disadvantage, as the trawl lies flaccid on the bottom until the warp

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The blueback trout (Salvelinus oquossa) mentioned here is possibly synonymous with S. alpinus.--The EDITOR.

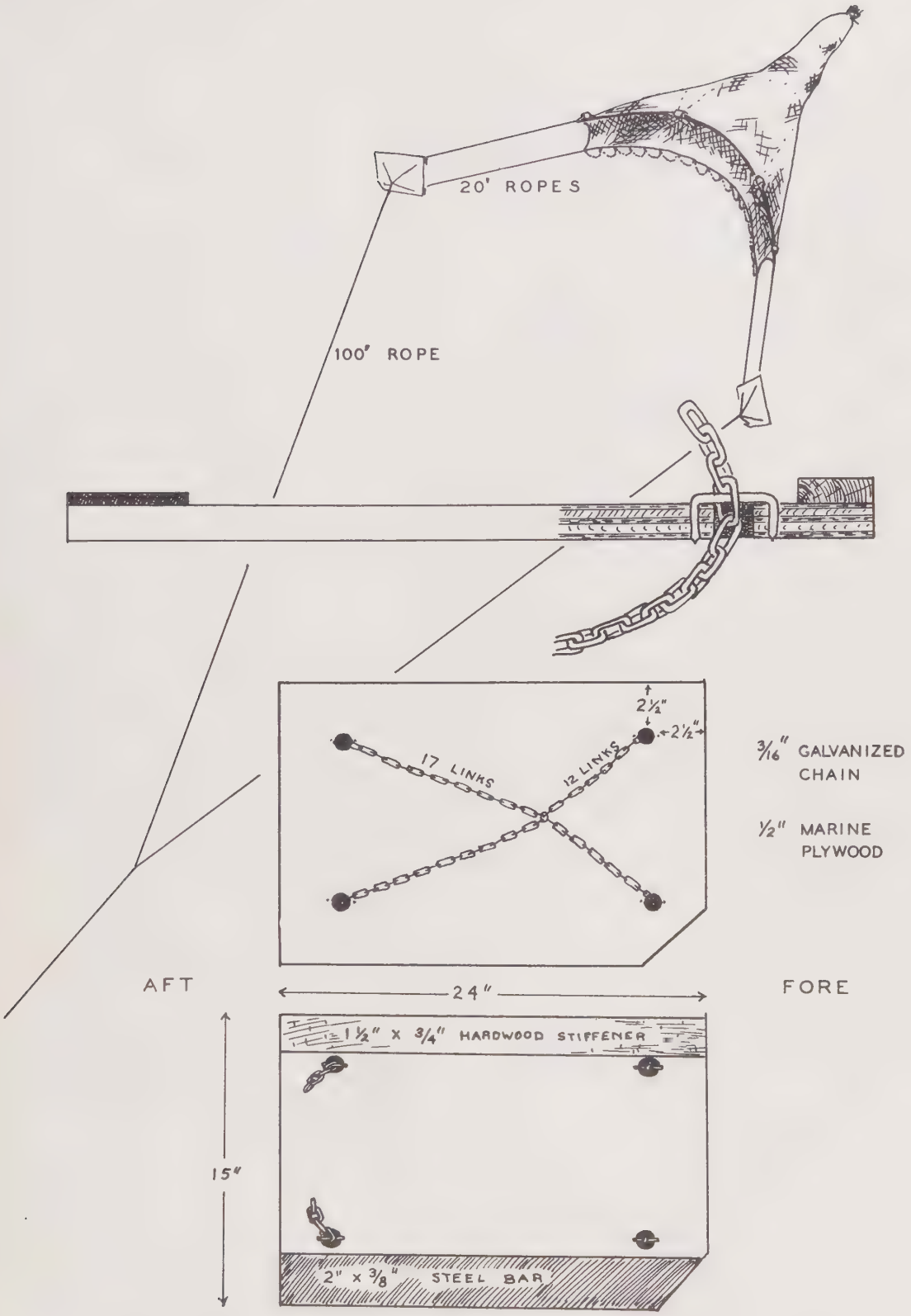

FIGURE 1.--Maine otter trawl: general rigging scheme and otter board details.

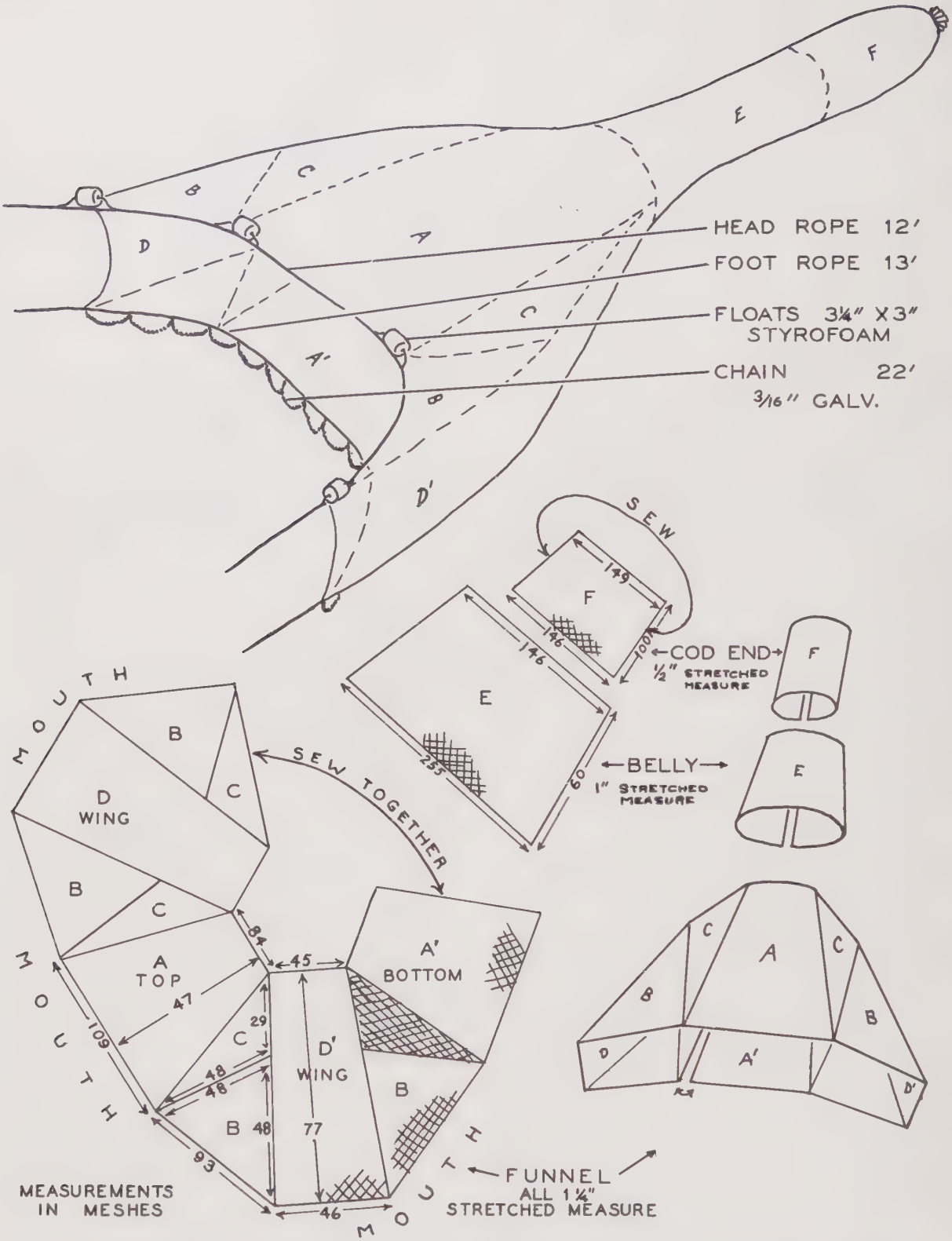

FIGURE 2.--Maine otter trawl: net construction details. Netting may be nylon or cotton. Head rope, foot rope, and leg lines are 1/4-inch manila or 3/16-inch nylon. Note use of 22 feet of chain for 13 feet of foot rope.

has been pulled into the boat. While the trawl lies on the bottom, fish no doubt escape. This loss was reduced by sewing a funnel-like net flap in the forward portion of the cod end. Another modification which we plan to try soon will consist of a pursing line threaded around the forward portion of the cod end and leading to the boat so that the cod end can be pursed into a closed bag as soon as the motion stops. It is hoped that this will prove more effective than the present net fyke. The need for some means of keeping the fish in the cod end while the trawl is motionless is strongly suggested by the fact that the collection of weeds and other debris in the cod end is usually accompanied by increased efficiency; the fish become entangled and escape much less readily. When the cod end contains little trash, it often contains few fish also.

The escape of fish while the trawl is being hauled aboard could probably be prevented most effectively by devising some arrangement to pull the trawl while underway. To this end, a hand-operated winch with ratio 1:5.3 was tried while using 1/8-inch galvanized-wire rope as towing warp. This apparatus provided sufficient power to pull the trawl while underway, but the operation was too slow. We are now working on the development of a light, compact, motorized unit.

When towing with wire rope rather than manila, the depth-to-warp-length ratio appears more important. Use of excessive warp causes the trawl to "dig in" on soft bottoms. Careful adjustment of the warp length will be necessary when trawling with wire rope; it may be necessary to use a small fathometer to make periodic checks of water depth along the trawling course.

Chafing gear is almost always needed in the large otter trawls used in marine commercial fishing. We have not found that chafing gear is needed for trawling fresh-water lakes.

When the trawl is used on unfamiliar areas in Maine lakes, there is always the possibility of hanging up on rocks, sunken tree tops, or other debris. We have found it necessary to have SCUBA gear handy to recover the trawl if it can be worked loose in no other way. When trawling on established sampling courses, this is obviously no problem.

We shall welcome correspondence from other fishery workers who can make suggestions for the improvement of our gear or procedures, or who would like more information about our experiences with otter trawling in inland lakes.

A SELECTIVE DISEASE AGENT IN PERCH

A selective kill of yellow perch in Daily Lake, Montana, in May 1959--originally believed to be delayed winterkill--has been established by the Western Fish Disease Laboratory, Bureau of Sport Fisheries and Wildlife, as the result of a bacterial disease epizootic. The etiologic agent, an undescribed Pseudomonas, has been taken from minute lesions in the dorsal musculature and visceral organs of dying perch. The disease has been reproduced in perch in the Seattle, Washington, laboratory with suspensions of stock cultures of the original isolate.

Other species--including rainbow trout, brown trout, silver trout, black crappie, fine-scaled suckers, and rainbow x cutthroat hybrids--inhabit this lake, but only one black crappie (not available for bacteriological examination) was noted in the kill. Under the circumstances, it seems highly probable that the bacterial agent of this disease is singularly host specific.

Studies are projected to establish the degree of host specificity of the organism, and determine its effect on perch of different ages under varying conditions of temperature and nutrition.

A UNITIZED SYSTEM OF WATER-LEVEL AND FISH-POPULATION CONTROL STRUCTURES FOR SPAWNING SLOUGHS

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DURING THE STUDIES OF THE LIFE HISTORY OF NORTHERN PIKE at Lake George, Anoka County, Minnesota,[1/] it was necessary to design structures to regulate water levels and fish movements in a shallow spawning slough. The present description of these devices has been prepared in the hope that it will be useful to others facing similar problems.

The basis of the installation is a water-level control structure of interlocking metal sheet piling placed in the slough outlet. This structure was installed with stop logs inserted into channels welded to the sheet piling. Precise control of the water levels--particularly the maintenance of small but steady outflows during the emigration of fry--was difficult with these logs, and they were replaced with a watergate (figure 1) constructed as a unit. The small stop logs of this watergate are approximately 1 inch high and 18 inches wide, making it much easier to conserve water while still permitting outflow during periods of low runoff. For unusually heavy discharges, the entire gate may be adjusted in the guide channels to permit additional flow beneath it.

The watergate also serves as a point of attachment for fishways, fry traps, and similar pieces of equipment. A simple Denil-type fishway (figure 2) constructed of stock lumber can be inserted in the fishway by removing enough of the small stop logs so that the floor of the fishway is several inches below the slough level. If the water level drops, more stop logs can be removed and the fishway dropped deeper into the gate. The structure can be lifted from the gate easily with a chain sling and a pair of automobile bumper jacks. Seals at the point of insertion are conveniently made by driving a pair of wooden strips into the stop-log channels. Control of water levels while the fishway is being installed is provided by a hinged board at the upstream level.

Exact dimensions of the fishway have not been indicated because these will be determined by the individual installation, but there should be a free passage of at least 10 inches between the baffles and the maximum slope should not exceed 1 to 10. The baffles are essential on both sides and bottom. Unbaffled chutes permit velocities too high for easy ascent by fish and also require a substantially higher discharge to provide adequate depth and flow of water in the fishway.

The fishway is shown in place in figure 3. In the photograph, a unit containing a fish counter has been attached to the upstream end. Weirs made of hardware cloth guide fish into the fishway at either end. If a trap is required for counts or samples of fingerlings, the gate should be provided with trap seals to aid in fitting the trap tightly to the

[1/] This work was supported by the Minnesota Department of Conservation as part of Dingell-Johnson Project F-12-R.

Paper No. 4258 of the Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

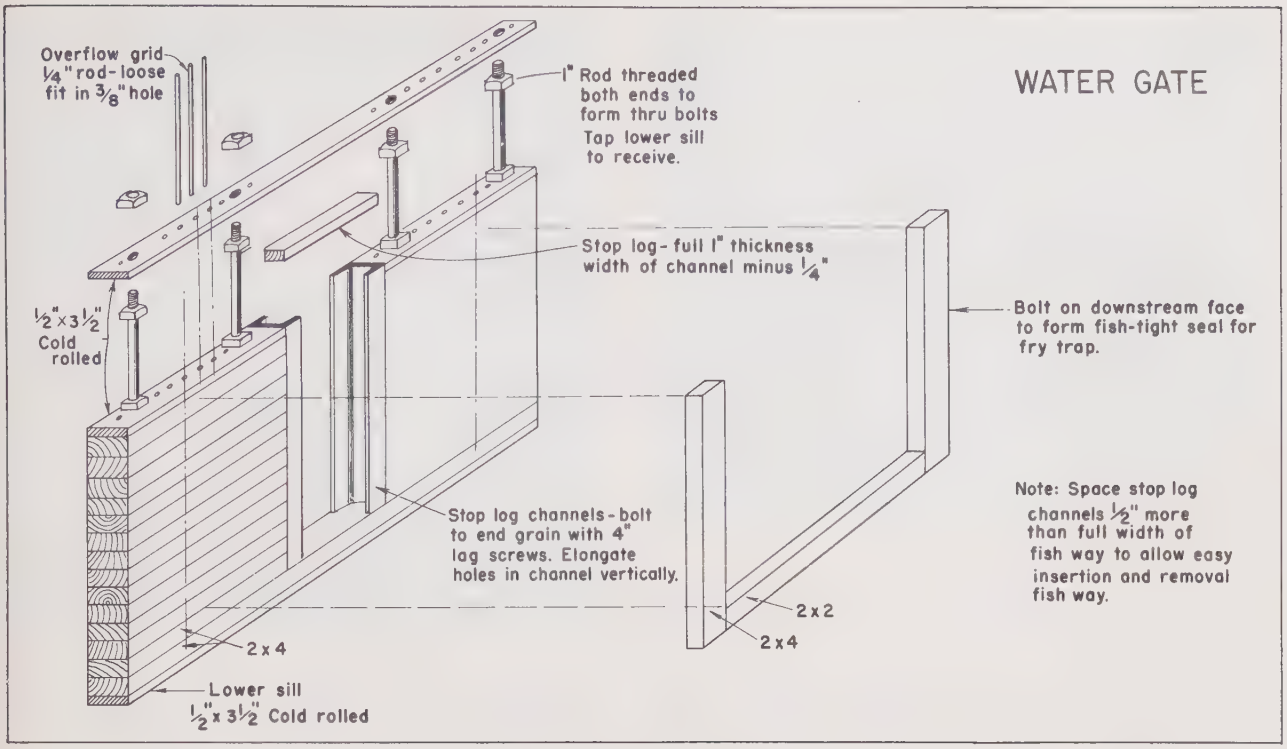

FIGURE 1.--Watergate for insertion into sheet-piling control structure.

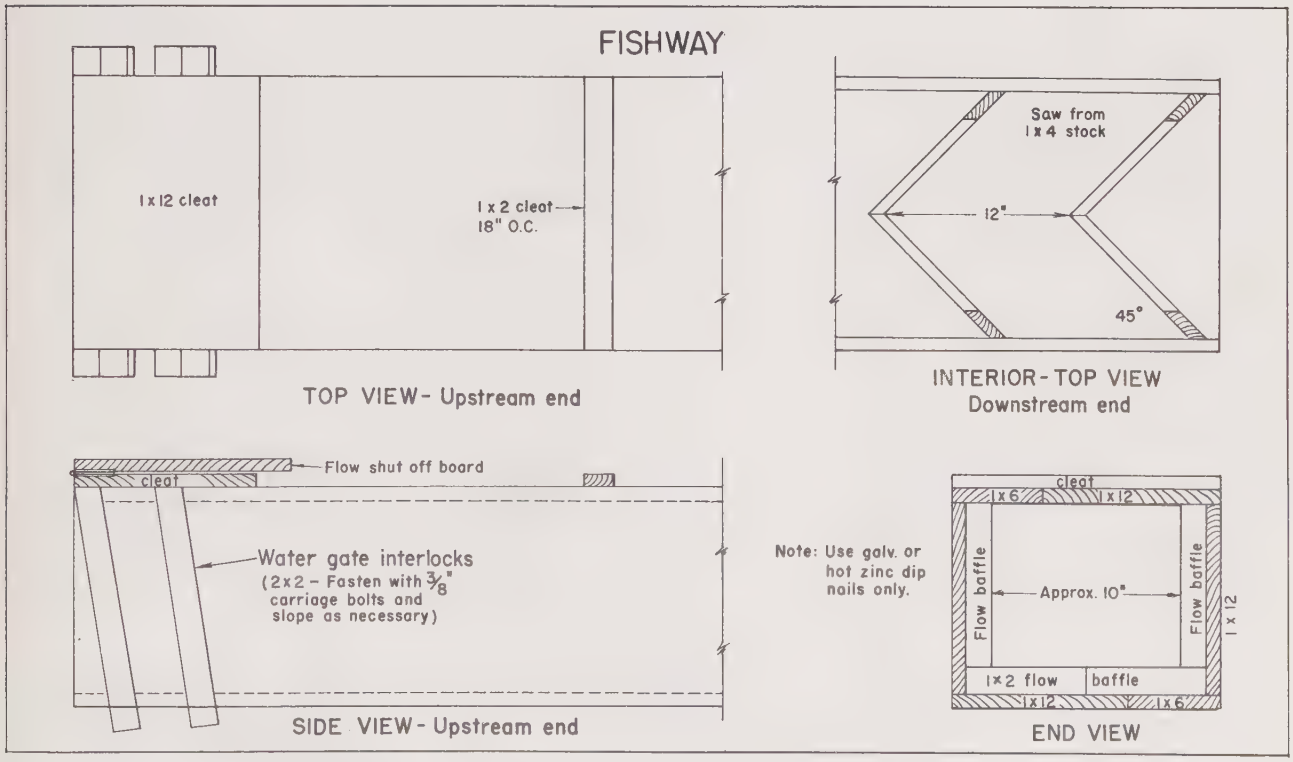

FIGURE 2.--Fishway for insertion into watergate.

FIGURE 3.--Denil-type fishway installed in watergate.

FIGURE 4.--Fingerling trap attached to the watergate, showing interior baffle to divert excessive flow.

face of the gate. The trap shown in figure 4 is recessed into these seals and held to the watergate with a pair of ordinary hasps. It is a simple box of marine plywood, with side and end screens of 0.125-inch hardware cloth. A V-shaped interior baffle, which clears the sides of the box by about 1 inch, shunts most of the flow to the outside through the screens. This diversion of water and creation of a still pond behind the baffle is necessary to prevent injury and death of the confined fingerlings. The end and side screens are removable for cleaning or to permit free passage of fish without removing the trap. The trap does not interfere with the use of the stop logs of the watergate for flow control.

The steel grate rods at the top of the watergate are not essential, but they help to protect the fishway or trap from debris during periods of heavy outflow.

The possibility that threespine sticklebacks (Gasterosteus aculeatus) may be reservoirs for parasites and diseases in trout is being studied at the Western Fish Disease Laboratory of the Bureau of Sport Fisheries and Wildlife in Seattle, Washington. Of nine different parasites already observed in threespine sticklebacks, at least six are known to occur or are likely to occur in rainbow trout in the same study area.

The Fish-Pesticide Research Laboratory of the Bureau of Sport Fisheries and Wildlife in Denver, Colorado, reports that 7 months after Clayton Lake, New Mexico, had been treated with 0.05 part per million of toxaphene, analyses of the tissues of seven groups of black bullheads (Ameiurus melas) showed 0.0034 to 0.0075 part per million of toxaphene.

A NEW METHOD AND A NEW MATERIAL FOR SCREENING FISH

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THE SCREENING OF FISH, to prevent either ingress or egress, is a universal problem. Our particular problem at the McGraw Hydrobiological Laboratory is to prevent the ingress of fish into experimental ponds along with the water supplied from reservoirs that have abundant warm-water fish populations. As the experimental ponds are scattered over several hundred acres of ground, no single, centralized filtering unit can be used. It is necessary to screen water at all seasons, rather than during the fall and winter when young-of-the-year fish are usually large enough to be stopped by a comparatively coarse screen. Our need is for a portable filtering system that is capable of screening fish eggs as well as the smallest fry.

Initial screening efforts included several designs for filter boxes that featured metal screens. These boxes were attached to the outlet pipes of the valves which controlled the flow of water into the ponds, so that the water passed through the valves, through the filter boxes, and into the ponds. Most of those systems worked very well, and some are still used during seasons when the fish are of post-fry sizes and the water supply is relatively free from algae, leaves, and other debris. At other seasons, however, fish and debris invariably clog the screens, and, if not cleaned frequently, the clogged screens will burst. The solution seemed to be one of increasing the screening surface or reducing the water pressure.

Our systems now in use for removing fish eggs and newly hatched fry employ a fabric known as Saran Filter Cloth, marketed by the National Filter Media (New Haven, Connecticut) as MS-904 Saran Screen. This is a durable plastic, resistant to acids and rot. It has a thread count of 52 x 52 per square inch, with yarn 0.008 inch in diameter. The square pores in the fabric have been computed to be within a range of 0.010 to 0.012 inch in diameter. The weave is tight and does not slip, owing to the fact that it is a twill rather than a plain weave. We use the material in two ways: (1) in the form of a bag, approximately 14 inches in diameter and 6 feet in length, which is tied over the valve outlet supplying the pond; and (2) as a lining for a large filter box, which floats in the pond and receives the water through a canvas tube connected to the outlet.

The bag system, using material which is probably similar to our plastic cloth, has been successfully employed in Israel to screen fish from carp ponds. Pruginin (1956) described fitting water pipes that led into the ponds with bags of a plastic window-netting produced by "Saran" (his quotation marks). The term "window-netting" implies a coarser screen than ours. Pruginin reported no functional difficulties when the bag was used over a period of several months; he found that the bag needed to be emptied only once each month.

Bags made from MS-904 Saran functioned well as filters if certain precautions were taken. When the bags were left on the pipes between periods of use, rodents or other small animals occasionally gnawed holes in these bags for the

FIGURE 1.-- The filter box lined with Saran screen. The box is anchored to a frame extending from shore and is connected to the valve outlet by a canvas tube. The frame limits horizontal movement but not vertical, so that the box floats as the pond level rises.

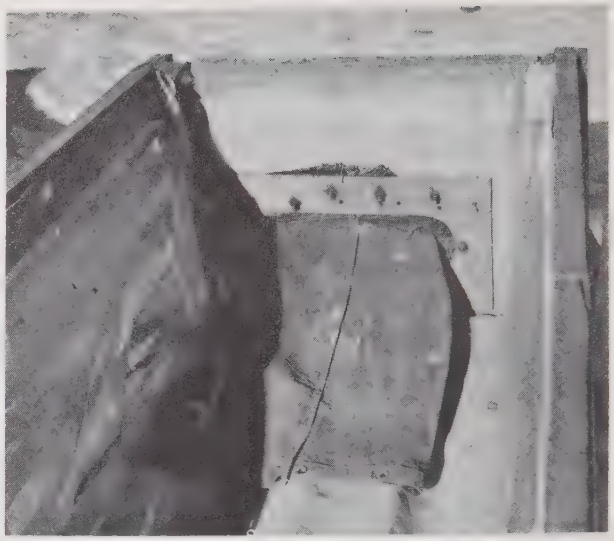

FIGURE 2.--The method of attaching the canvas tube to the filter box. A collar on the tube is bolted between two plywood supports which, in turn, are bolted to the framework of the filter box.

apparent purpose of feeding on the accumulated fish, plankton, insects, and other material. Rats and mice damaged the bags when they were improperly stored indoors. Also, the material appeared to weaken with time and use, so that the bags were not dependable after approximately 1 year of intermittent use. Our present practice is to renew the bags every 6 to 8 months, and to use them only when comparatively small volumes of water are to be screened, as in the partial filling of a pond. For the complete filling of 1-acre ponds, where we often screen flows of 500 to 800 gallons per minute, we have greater confidence in the filter box that is described below.

The basic design of the floating-type filter box was suggested by Mr. Andrew Kromhout (of the Elgin Softener Corporation, Elgin, Illinois), a specialist in the design of industrial filters. The box operates on the principle that having water on the outside of the box as well as on the inside tends to equalize the pressure on the screen. Water filters from the box under reduced pressure, and the screened materials circulate rather freely within the box instead of being pressured against the screen in such a way as to clog the pores. Tests with scale models led to the present design (figure 1). The box rests on the pond bottom at the beginning of the filling process but floats in a partly submerged position as the water level rises. The framework of the box is constructed of 1 x 2-inch pine lumber, in the dimensions of 24 by 32 by 84 inches. A framework to hold the box in position is 16 feet long, constructed of 2 x 3-inch lumber. A permanent base for attachment has been constructed at each pond. This consists of two vertical pilings of 2-inch pipe, set parallel to the bank, separated by about the width of the box (32 inches), and connected by a crosspiece of pipe between them. The framework for holding the box is attached to this crosspiece so that it can pivot in the vertical plane. The opposite end of the framework is attached to the sides of the box (figure 1) so that both framework and box have free movement in the vertical plane but retain stability in the horizontal plane. A canvas tube connecting the valve outlet and the box enters the box through an oval opening (figure 2) and is secured to the box--and to the filter lining--by means of a collar sewn onto the tube about 3 feet from its outlet. The collar is bolted to the screening fabric by sandwiching both between two thin sheets of plywood, which, in turn, are bolted to the framework of the box.

This filter box has been successfully operated without a cover during many pond-filling operations. Recently, however, we have added a screened cover in the event that the box should become overturned or submerged while in use.

The floating box, with the original filter lining, has been operational for approximately 18 months. After approximately 1 year of intermittent use, it was necessary to patch several small worn places that would have developed into holes. While our 1-acre ponds are being filled, the box screens about 6 acre-feet of water without servicing or cleaning. The flow of water into some ponds is in the range of 500 to 800 gallons per minute. The size of filter box required depends, of course, on the volume and rate of flow of water to be screened, and on the amount of organisms and debris in the water. In our work, we believe that we could safely reduce the size of the present box to 24 by 30 by 60 inches.

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TROUT STOCKING BY AIR DROP OF PLASTIC BAGS

As many lakes in the area of the Winthrop National Fish Hatchery (Washington) cannot be stocked successfully except by aircraft, tests were made in August 1959 to determine the best use of plastic bags in this work. The bags were 30 inches long, tapered from a 21-inch diameter at the bottom to 36 inches at the top, and--as they were not watertight at the bottom seam--had to be secured with rubber bands. Tests were made with bags containing 2 gallons of water each and the following quantities of rainbow trout (480 per pound):

1. One pound of fish. Water temperature was 53° at start, 59° at end. Fish held well for 25 minutes, were distressed in 30, and began to suffocate in 35. When the test ended (37 minutes), 150 were dead.

2. One-half pound of fish. This bag was floated in a trough of water at 56°. Fish held well for 35 minutes but showed signs of distress at 37 minutes.

3. One-half pound of fish. Excess air was pressed from the bag (which was set on the floor) and replaced with oxygen at about 3 pounds of pressure. The top of the bag was secured with rubber bands. Water temperature was 53°. Fish were held 2 hours with no sign of distress.

4. One pound of fish. Air was replaced with oxygen and the top secured with bands, as in test 3. Water temperature was 52°. Fish were held 1.5 hours with no sign of distress.

On the basis of these tests, we put 2 gallons of water and 0.5 to 2 pounds of fish in the plastic bags, replaced excess air with oxygen at about 3 pounds of pressure, secured the bags and put them in a distribution tank that contained ice and 5 inches of water, and transported the tank and bags to the airport. Here we took the bags from the tank, dried them, and laid them on the floor of the aircraft. When it was just over the lake, we held the bags just outside the aircraft and, with a sharp knife, made a small hole in each before dropping them. When they struck the water, the bags split open and sank.

This procedure was followed during the stocking of 1,500 trout in Slate Lake and 500 trout in South Lake. Stocking time, from take-off to drop, was only 42 minutes.

--FRED W. BITLE, Bureau of Sport Fisheries and Wildlife, Winthrop, Washington.

SYSTEM TO WARN OF WATER STOPPAGE IN HATCHERIES

This system has been devised to warn personnel of the National Fish Hatchery at Marion, Alabama, of a water stoppage in the holding house.

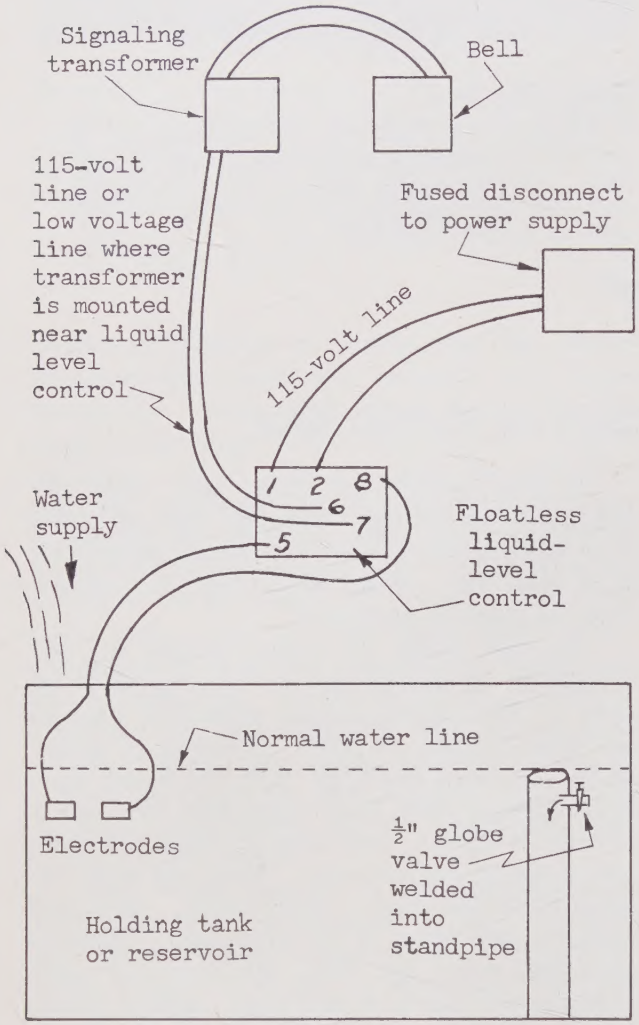

FIGURE 1.

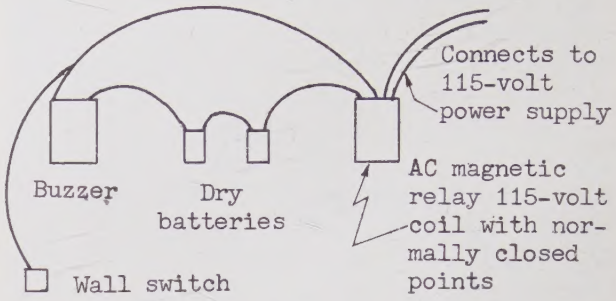

FIGURE 2.

One holding tank is used as an indicator (figure 1). A half-inch valve is welded in an opening cut through the side and about 6 inches below the top of the standpipe. With the valve open and the water cut off, the water level falls to that of the valve in about 10 minutes. The electrodes of a floatless liquid-level control, suspended in the tank about 4 inches below the normal water level, are connected to a signaling transformer. This, when the water level falls below the electrodes, operates a bell.

As the system in figure 1 is powered by electricity, the setup in figure 2 is used to warn of power failure. An alternating-current magnetic-relay 115-volt coil with normally closed points connects the power supply and two 6-volt dry batteries in series that can start a buzzer. Power failure opens the points, making the buzzer sound. When noted, the buzzer can be shut off and measures taken to avoid fish loss.

Materials and parts, exclusive of the wire from the holding house to the bell and buzzer, cost approximately $55.

--JACK R. SNOW, Bureau of Sport Fisheries and Wildlife, Marion, Alabama.

CHANGE IN DATES FOR SYMPOSIUM ON COLLECTION AND UTILIZATION OF WATER-QUALITY DATA

The Public Health Service has announced that the dates for this symposium--previously announced as August 23-25, 1960 (THE PROGRESSIVE FISH-CULTURIST 22 (2): 80)--have been changed to August 29-31, 1960. All other details remain the same.

TO CONTRIBUTORS

Contributions for publication in THE PROGRESSIVE FISH-CULTURIST are always welcome. All contributions should be directed to: The Editor, THE PROGRESSIVE FISH-CULTURIST, Bureau of Sport Fisheries and Wildlife, Washington 25, D. C.

Manuscripts should be typewritten, double-spaced, on one side of white bond paper. Illustrations should be in the form of sharp, glossy, black-and-white photographs or drawings prepared with waterproof black India ink on heavy white paper or tracing cloth.

A short abstract should be submitted with each manuscript. When an article has appeared in an issue of THE PROGRESSIVE FISH-CULTURIST, the publication data will be added to the abstract and this will then be forwarded to Biological Abstracts and Sport Fishery Abstracts.

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